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NATIONAL GEOGRAPHIC

THIS BABY WILL LIVE TO BE 120*

*It's not just hype. **New science could lead to very long lives.**

Refuge on Wrangel Island 50
Courage in Zimbabwe 72
Fertilize the World 94
Hunting for New Elements 112
China's Grand Canal 126

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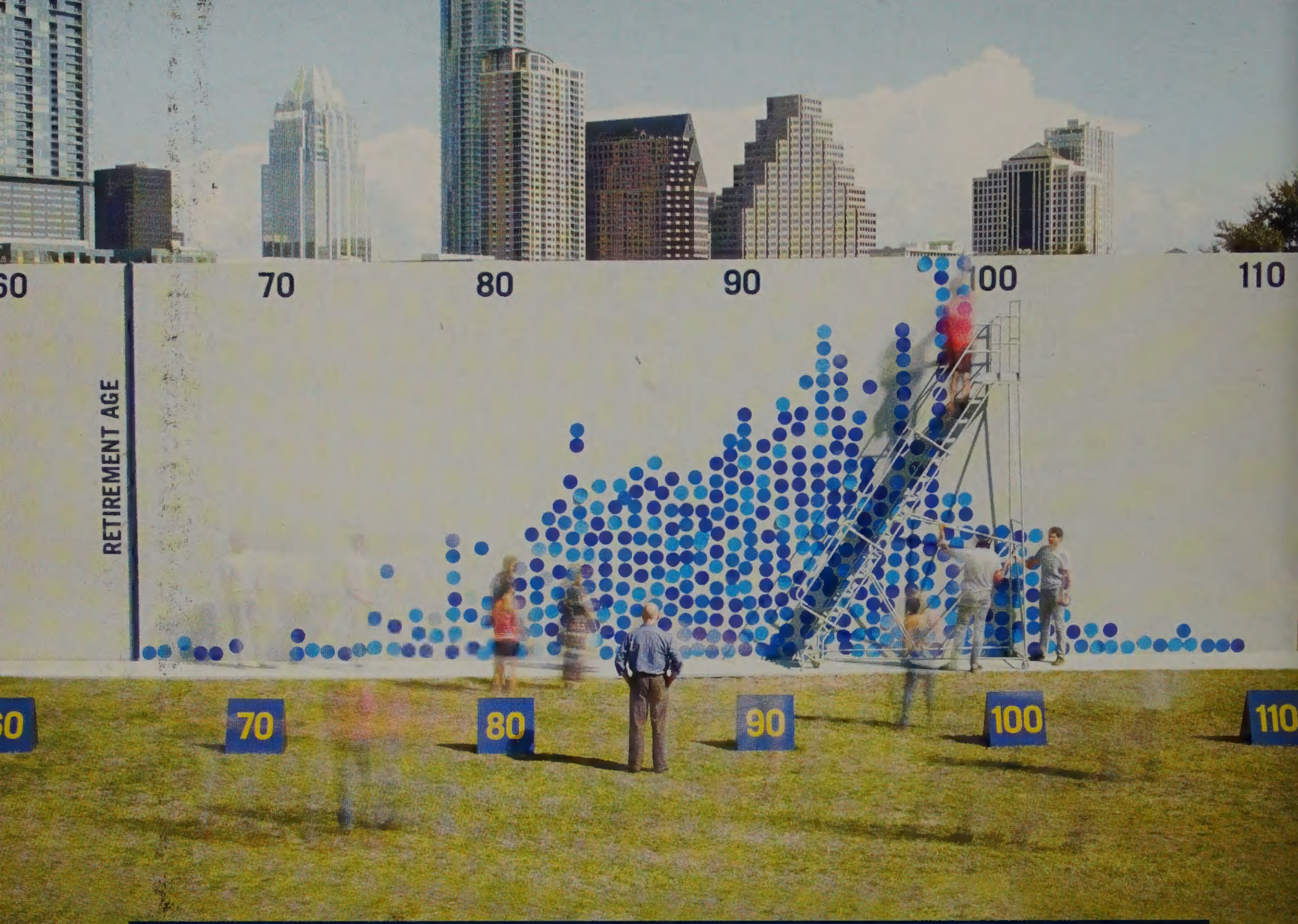

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VOL. 223 • NO. 5

NATIONAL
GEOGRAPHIC

"I am like that tree.
I've had my branches cut,
but I am not dead."
page 92

May 2013

28 **New Clues to a Long Life**
You want to live to 120? And stay healthy? Genetic discoveries could make that wish come true.
By Stephen S. Hall Photographs by Fritz Hoffmann

50 **Siberian Sanctuary**
Wrangel Island was once thought to be a magical realm. That's not so far from the truth.
By Hampton Sides Photographs by Sergey Gorshkov

72 **Unsilent Zimbabwe**
The violent rule of Robert Mugabe has shattered a nation. But he cannot still the voices of the people.
By Alexandra Fuller Photographs by Robin Hammond

94 **The Curse of Fertilizer**
Could agriculture destroy our planet?
By Dan Charles Photographs by Peter Essick

112 **Element Hunters**
A new atom is born. And then it vanishes. And the search for undiscovered elements goes on.
By Rob Dunn Photographs by Max Aguilera-Hellweg

122 **Turning Old Things Into New**
Shrimp shells + silk protein = one of many freshly minted (and super-useful) materials.
By A. R. Williams

124 **Flying in the Face of Peril**
Bears, snakes, and unhappy bureaucrats can't stop Çağan Şekercioğlu from saving birds.
By Jeremy Berlin Photograph by Marco Grob

126 **China's Grand Canal**
The ancient waterway linked north and south for centuries. Nowadays it's a tourist draw too.
By Ian Johnson Photographs by Michael Yamashita

The arctic foxes of Wrangel Island share turf and surf with a variety of animal neighbors, from polar bears to Pacific walruses.

SERGEY GORSHKOV

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY

May 2013

4 **Editor's Note**
6 **Letters**
8 **Survival Guide**

10 **VISIONS ▸**

16 **Your Shot**

19 NEXT

The Fiery World of Dinos

Lightning struck. Wildfires raged. Dinosaurs had to deal with it.

Explorers Quiz ▸

Topic: mapping the world. Sample query: What were likely the first maps?

Flying Dutch

An elevated ring lets pedestrians and cyclists soar over traffic jams.

Buried in a Glacier

Should we try to recover the icebound victims of a 1940s military plane crash?

Heavenly Record of Earth

Find out what's on the disc that's been hurtling through space since 1977.

Pistachio Geopolitics ▸

Iran used to be the top producer. Then nature and sanctions took a toll.

142 **NG Connect**
144 **The Moment**
Flashback

NATIONAL GEOGRAPHIC
THIS BABY WILL LIVE TO BE 120

On the Cover As scientists unlock genetic answers to a long life, the Jewish blessing "May you live to be 120" could become reality. To illustrate that idea, we couldn't resist a quartet of cover babies, distributed at random (clockwise from top left): Remus Jeong, Norah Reeps, Aliya Allen, and Soleil Chennault
Photos by Robert Clark

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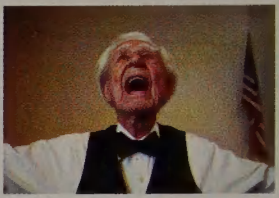
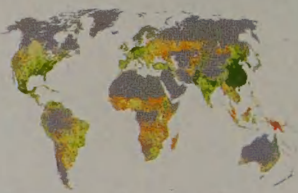


How to Live Long
Video
Thriving seniors share their secrets.

Wrangel's Wild Wonders
Video
Owls, foxes, and polar bears rule this remote isle.



Fertilized World
Interactive Graphic
See where nitrogen is too much of a good thing.

PHOTOS: FRITZ HOFFMANN (TOP); SERGEY GORSHKOV

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AUSTRALIA
Indian Ocean

Quokka *(Setonix brachyurus)*
Size: Head and body length, 40 - 54 cm (15.7 - 21.3 inches); tail, 24.5 - 31 cm (9.6 - 12.2 inches)
Weight: 2.7 - 4.2 kg (6.0 - 9.3 lbs) **Habitat:** Dense swamps, heath, thickets, low forest and waterside areas **Surviving number:** Estimated at 7,850 - 17,150 mature individuals

Photographed by Jean-Paul Ferrero

WILDLIFE AS CANON SEES IT

Heir and a spare. The female quokka is equipped with a pre-embryonic structure called a blastocyst, which develops into an embryo if her joey dies before becoming independent enough to leave the pouch. Nature has also endowed the quokka with bacteria in its gut capable of breaking down the poor-quality vegetation in its environment. Terrestrial but able to climb trees and small shrubs, the little marsupial browses for leaves and grass, and searches out the best shelter from the sun in the scorching summer. But all its natural advantages avail it little against the threats of foxes, feral cats, habitat loss and disease.

As we see it, we can help make the world a better place. Raising awareness of endangered species is just one of the ways we at Canon are taking action—for the good of the planet we call home. Visit **canon.com/environment** to learn more.

Canon

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EDITOR'S NOTE

Food and Water

There is a stream on my property in Rappahannock County, Virginia, that meanders through fields in its own sweet time, in its own sweet way. It's a thread of water, narrow enough for me to leap over, modest in the grand scheme of nature, but I take my responsibility as its caretaker seriously. I keep wandering livestock out of the stream. I know their nutrient-rich manure turns water eutrophic, the scientific term for water overloaded with nutrients. I don't mow grass along the edges but keep it long, as a buffer to absorb any fertilizer runoff from the fields, which could ultimately end up in the Chesapeake Bay and affect its fisheries. I try to be a good steward. The stream may be mine, but the water belongs to everybody.

In some parts of the world good stewardship of the land is a luxury, notes writer Dan Charles in this month's story "Our Fertilized World." It's not hard in the United States, but not so simple in countries like China, where there is less arable land per person than here. In Africa, where famine is a reality, the hope of high crop yields provided by fertilizer often carries more weight than concerns about environmental impact. The balancing act between feeding the world and ecological equilibrium is tricky. There are consequences on both sides. Still, when it comes to water, it's best to remember that we're all in this together.

The naturalist Aldo Leopold said that rivers are round. A river or stream is a cycle of energy from sun to plants to insects to fish. It is a continuum broken only by humans.

Chris Johns

Algae color the water beneath a mat of wheatgrass roots.

PHOTO: REBECCA HALE, NGM STAFF

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NATIONAL GEOGRAPHIC
EXPLORE

January 2013

Restless Genes

I beg to differ on the reasons for human migration to all corners of the world during the last 200,000 years. The last few hundred years of exploration represent less than one percent of human history and took place when humans had already occupied almost all the land on the globe. I believe that the migration of the human species in the other 198,000 years was the result of climate changes, a need for better foraging, and developed ways of living. Restlessness, curiosity, or a nomadic lifestyle did not play a role.

STAFFAN PERSSON
Madison, Alabama

"Why We Explore" is why I'm a member. You bring us from our living rooms into the cold, hot, remote, high, low, barren, overrun, infested, and otherwise amazing places of our world.

CHIP UNDERHILL
Merrimack, New Hampshire

The term "modern human" may mislead by suggesting a distinct line. Since many humans in western Eurasia carry evidence of Neanderthal genes, *Homo neanderthalensis* apparently successfully interbred with *Homo sapiens.* Denisovans also interbred with *Homo sapiens.* DNA sequencing of Filipinos, Melanesians, and Australian Aborigines points to Denisovan ancestors. Perhaps the map of human exploration should look more like a tangled wild rosebush than a single trailing vine.

KATHLEEN ROLLINS
Davisburg, Michigan

I am forever changed by travel and exploring. Thanks for letting me know I am not alone in my lifelong drive to "go there."

SHAYNA COONIN
Apollo Beach, Florida

Space Exploration

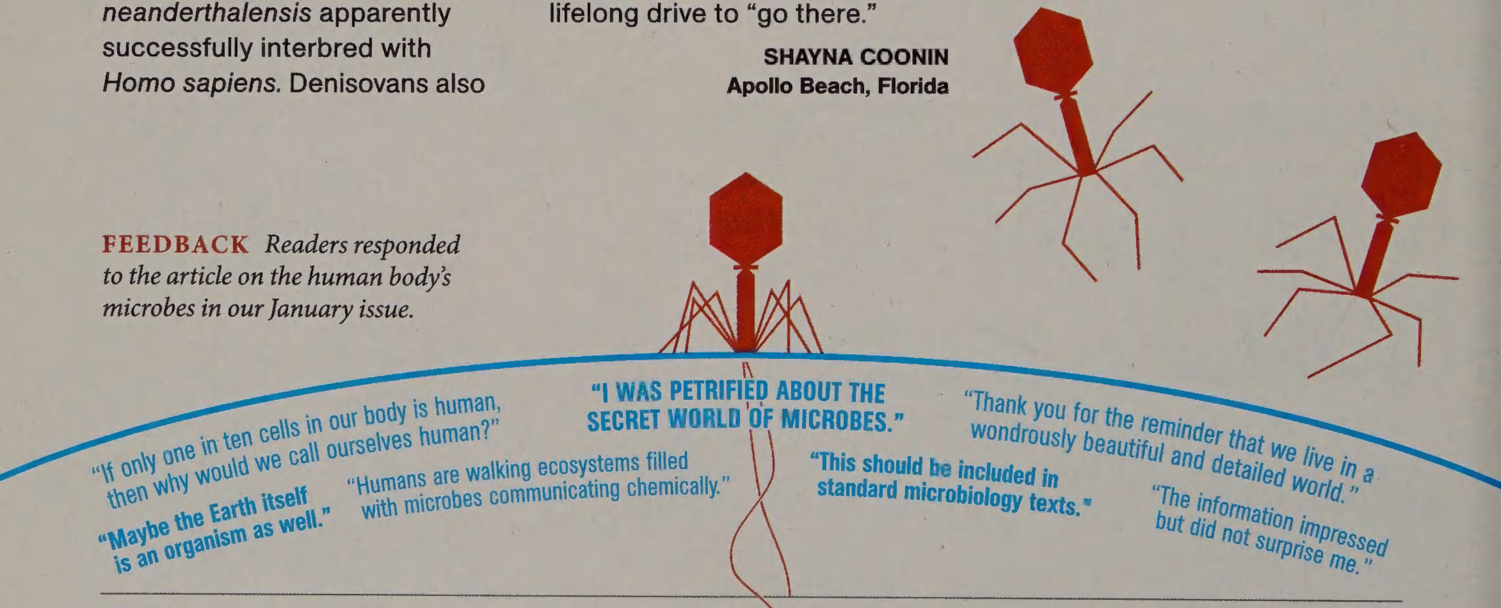
Author Tim Folger missed the most likely way humanity could colonize the galaxy—staggering given the nature of accompanying articles about islanders colonizing the vast Pacific with simple boats. The slow nomadic, or "island hopping," method is equally applicable to space. As humanity colonizes our inner solar system, primarily for energy needs and resource extraction, we eventually will be attracted to the resources of Jovian space and then the Oort cloud and Kuiper belt. Human migration has always been slow and steady, setting up a homestead just over the hill and eventually reaching an ocean.

KEITH PRETZER
Fresno, California

Corrections

JANUARY 2013, NEXT: QUIZ The correct longitudes for Easter Island and Moab, respectively, should have been 109° 26' W and 109° 32' W.

FEEDBACK *Readers responded to the article on the human body's microbes in our January issue.*



"If only one in ten cells in our body is human, then why would we call ourselves human?"

"Maybe the Earth itself is an organism as well."

"Humans are walking ecosystems filled with microbes communicating chemically."

"I WAS PETRIFIED ABOUT THE SECRET WORLD OF MICROBES."

"This should be included in standard microbiology texts."

"Thank you for the reminder that we live in a wondrously beautiful and detailed world."

"The information impressed but did not surprise me."

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GRAPHIC: KEVIN DICESARE, NGM STAFF

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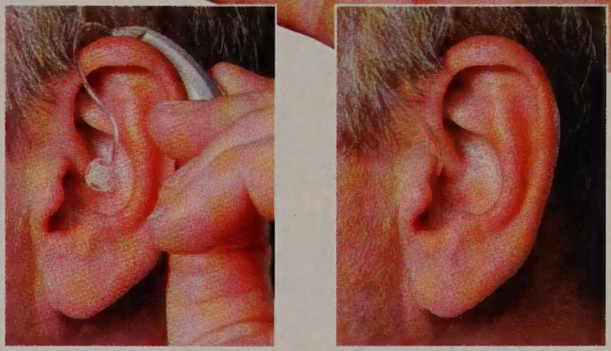

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Risk Takers

The articles about the risk takers were inspiring. They seem to be modern-day heroes doing such incredible things daily that they inspired me to actually put down the magazine and do some revision. If I'm ever even half as productive and life changing as they have been, I'll know I'm doing something right.

MELISSA ROSS
Cambridge, England

I quite enjoyed the 125th anniversary special issue. A question came to mind: I wonder how many of the people profiled as risk takers carry the *DRD4-7R* gene variant [discussed in "Restless Genes"]?

KEITH WILLIAMSON
Northglenn, Colorado

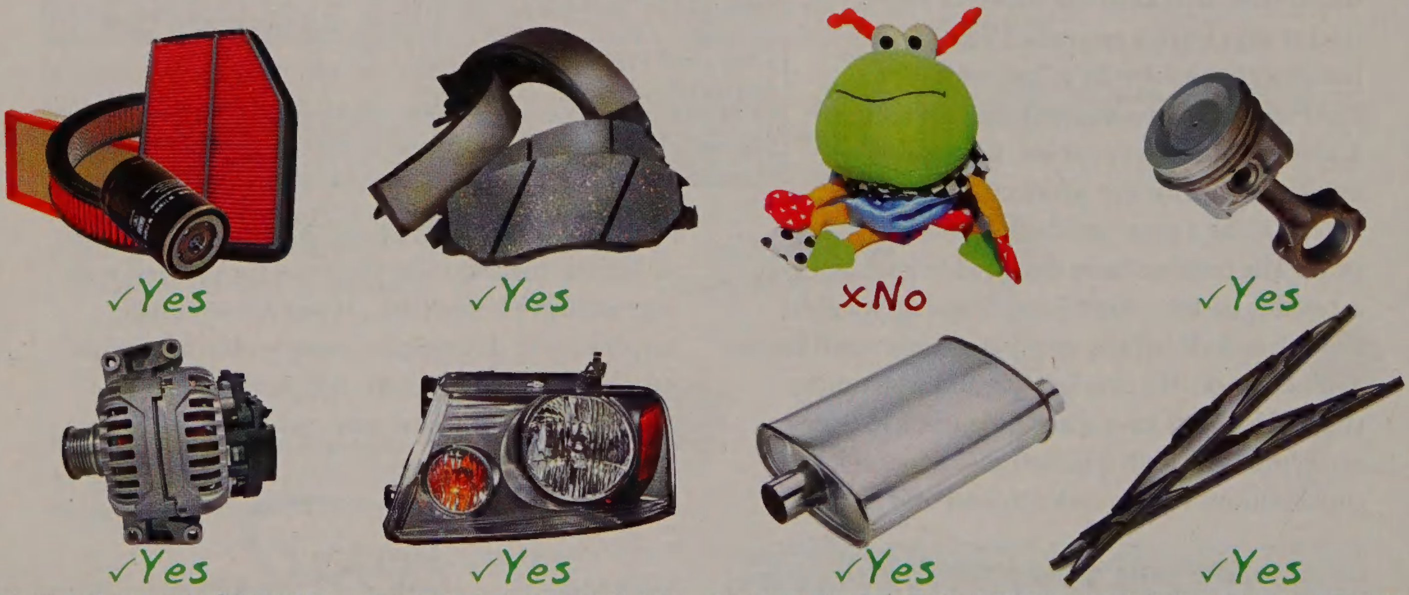
There are too many "man versus mountain" type articles. When a person climbs a mountain or descends into a cave or whatever, I don't want to hear about the person; I want to hear about the mountain or the people who dwell there.

GRETCHEN SAUER
Litchfield, Connecticut

Microbes

Thank you for an article that explains the way our body reacts and responds to the millions of both good and bad microbes. Whenever I read an article like that regarding the body, I am reminded of the psalmist who wrote, "I will praise thee; for I am fearfully and wonderfully made: marvelous are thy works; and that my soul knoweth right well" (Psalms 139:14). To think that the incredible complexities of the universe and our physical bodies somehow just happened over billions of years and that order came out of chaos takes more faith than the simple truth that God put it all together.

MARK POORMAN
Fridley, Minnesota



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150 Years Science For A Better Life

I've been a member for 50 years, and the cover reveals the draw. *National Geographic* has linked all ages all over the globe, using all types of photography to spread its message. The electron scan of strep on one of the five covers has reminded me how *NG* helped me become one with science and medicine.

PAUL LITTLER
Livonia, Michigan

Mawson Trek

Thank you for the article about Mawson and the Antarctic explorers. I had to stifle tears to finish the article. Reading about the remarkable compassion Mawson had for Mertz, as he served as a nurse to clean him, I paused to wipe my eyes. Then reading about how Mawson awoke covered in a thin coat of snow after his self-rescue from a crevasse—again, I paused to consider the story and wiped my eyes. Thank you, *National Geographic*, for sharing their story with me. It's no wonder Mawson was a hero in his home country of Australia. He's a hero to me too, in my own country and nearly a hundred years later.

KAMI HOLT
Highlands Ranch, Colorado

I salute the three stalwart outdoorsmen, eyes staring out from frigid cold a hundred years ago, seeming to look through me into some future that I myself cannot see.

CHARLES LEWIS
Medford, Massachusetts

Editor's Note

"The infinite horizon of possibility"—what a wonderfully descriptive and powerful statement. I may have it tattooed on my arm.

JIM OSAGE
Denver, Colorado

The innocence of children, nature's healing power, and art's capacity to immortalize—all in a tiny black-and-white photo.

KAY PANKRATZ
La Center, Washington

FLASHBACK: Prone Pilot

I was a flight surgeon at the School of Aviation Medicine in 1949 in ophthalmology. When we were doing research on this prone seat, we found that one-third of the pilots saw double in less than an hour, and this was the main reason it was rejected. A pilot must look up to see straight ahead, and this causes the eyes to pull apart—a condition called exotropia.

PAUL RIPPLE
Lancaster, Pennsylvania

Inspiring people to care about the planet

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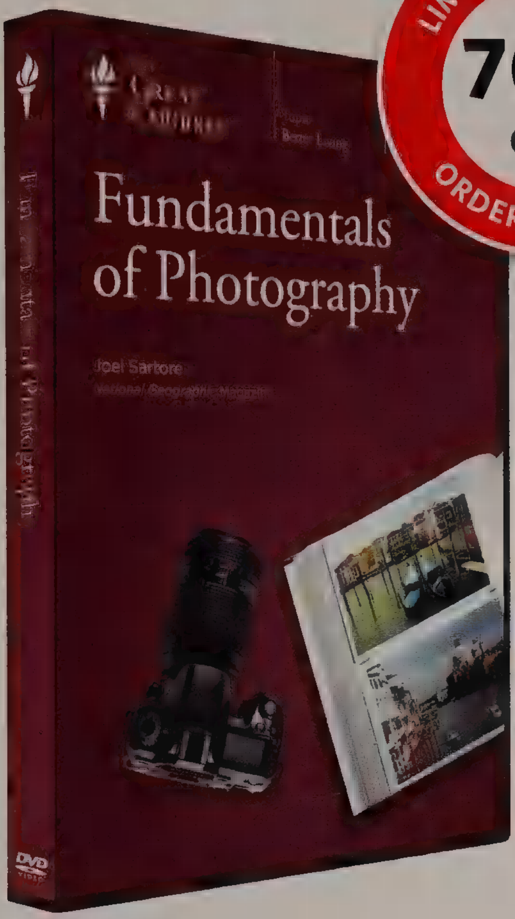

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Jeff Rose
National Geographic
Emerging Explorer

EXPERTISE
Human migration archaeologist

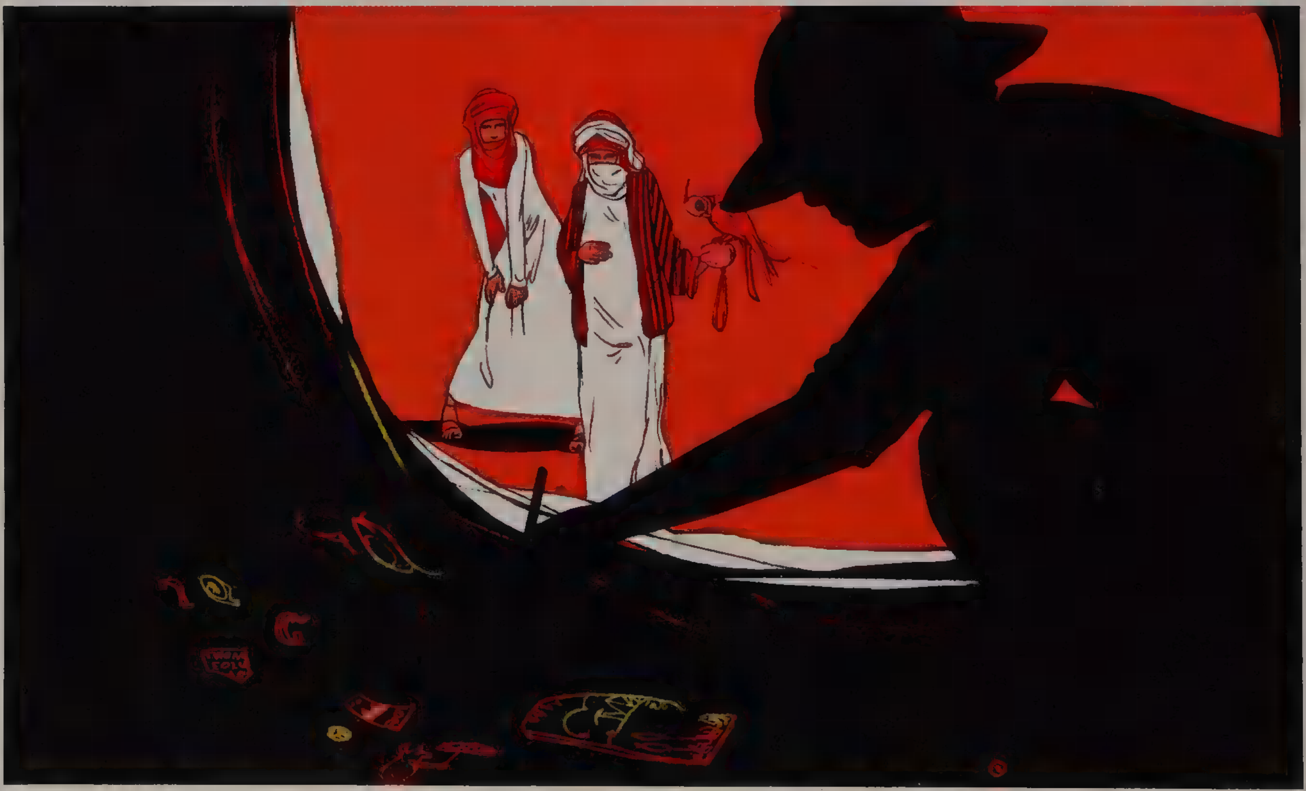
LOCATION
Oman

The Payout

My team members are from across the world—Ukraine, Germany, Italy, the U.S.—but often we don't have anyone from the Arabian Peninsula, where we dig for evidence of ancient humans. So during our first year in the field, before I'd learned Arabic and there was Google Earth to help, I took on a local Bedouin guide. When I asked his fee, he responded, "We are brothers. It is my joy to take you around these places." With a field budget of about $12,000 that had to cover equipment, car rental, and fuel, plus food and housing for eight men, I was more than happy to believe him.

Three days later, when it came time to part ways, he asked how much I was planning to pay him. I had no clue what he expected or what was considered fair, so I hesitantly offered the equivalent of around $50 a day. I'll never forget the look on his face—something between crestfallen and furious. I hadn't factored in that we work in the heart of Oman's petroleum industry, so the locals are used to being paid by oil companies, not tiny archaeological survey projects. I saw the whole summer of fieldwork at risk. To make matters more complicated, we had found incredible archaeology at the site he'd taken us to. He thought it was worth some money.

What alternatives did I have? Perhaps I would be put in prison for not paying. He ushered us into the car and began driving full speed back to his village. There his father, the sheikh, ordered me to pay $100 a day and buy a goat for $100 to celebrate the success of our project. I paid, they slaughtered, all feasted. We got out of there. These days we are mostly looking for caves, where sediments and stone tools are best preserved. The locals avoid the caves at all costs: They think jinn, or demon spirits, live in there. Fine by us.



ART: ISTVAN BANYAI. PHOTO: SCOTT DEGRAW

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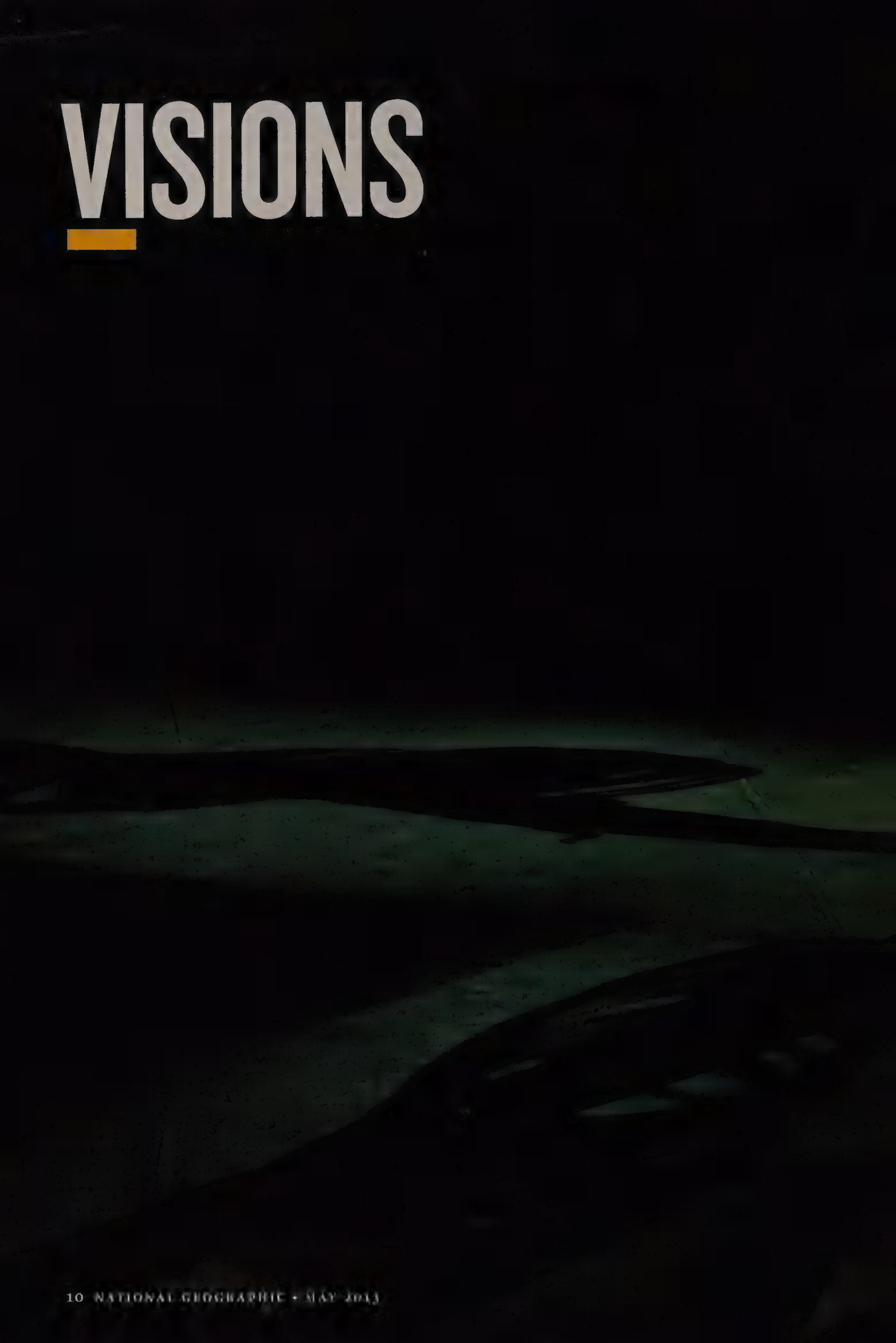
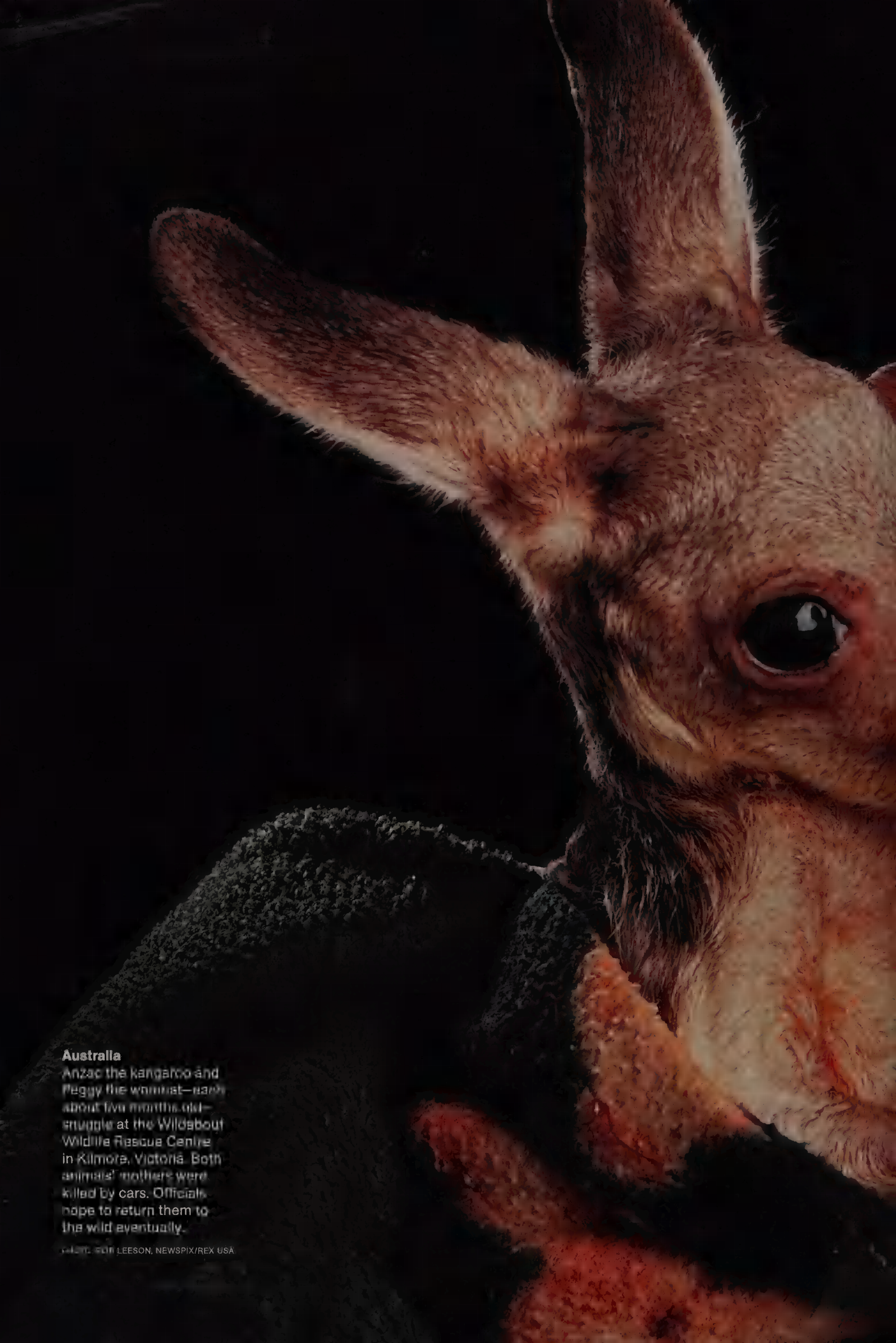


Russia
A rainbow of hula hoops swirls around Svetlana Pavlova, a dancer in a traveling circus troupe of short-statured performers who call themselves the Light of the Little Stars.

PHOTO: TATIANA [illegible]



Australia
Anzac the kangaroo and Peggy the wombat—each about five months old—snuggle at the Wildsabout Wildlife Rescue Centre in Kilmore, Victoria. Both animals' mothers were killed by cars. Officials hope to return them to the wild eventually.

PHOTO: ROB LEESON, NEWSPIX/REX USA

United States
Fireworks flash across a full moon on the third of July, part of early Independence Day celebrations last year at Pierson Park in Kansas City, Kansas.

PHOTO: CHARLIE RIEDEL, AP IMAGES

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This page features two photographs: one chosen by our editors and one chosen by our readers via online voting. For more information, go to *ngm.com/yourshot*.

EDITORS' CHOICE **Eva Kraaijenbrink** Leusden, Netherlands

At an animal show near Barneveld, Netherlands, this Angora rabbit was being inspected for the quality of its fur, which is often used to make luxury sweaters and scarves. "It was lying so still, it looked almost dead," Kraaijenbrink says. She zoomed in to see if it was still breathing. It was.

READERS' CHOICE

Sylwia Domaradzka
London, England

On a tour of central Poland's countryside last fall, Domaradzka saw many small battles between white-tailed eagles. These two birds in particular wanted to sit in the same spot. "There was an awful lot of fighting and bickering among them," she says.

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PROLOGUE

Though I often looked for one, I finally had to admit that there could be no cure for Paris. Part of it was the war. The world had ended once already and could again at any moment. The war had come and changed us by happening when everyone said it couldn't. No one knew how many had died, but when you heard the numbers—nine million or fourteen million—you thought, *Impossible*. Paris was full of ghosts and the walking wounded. Many came back to Rouen or Oak Park, Illinois, shot through and carrying little pieces of what they'd seen behind their

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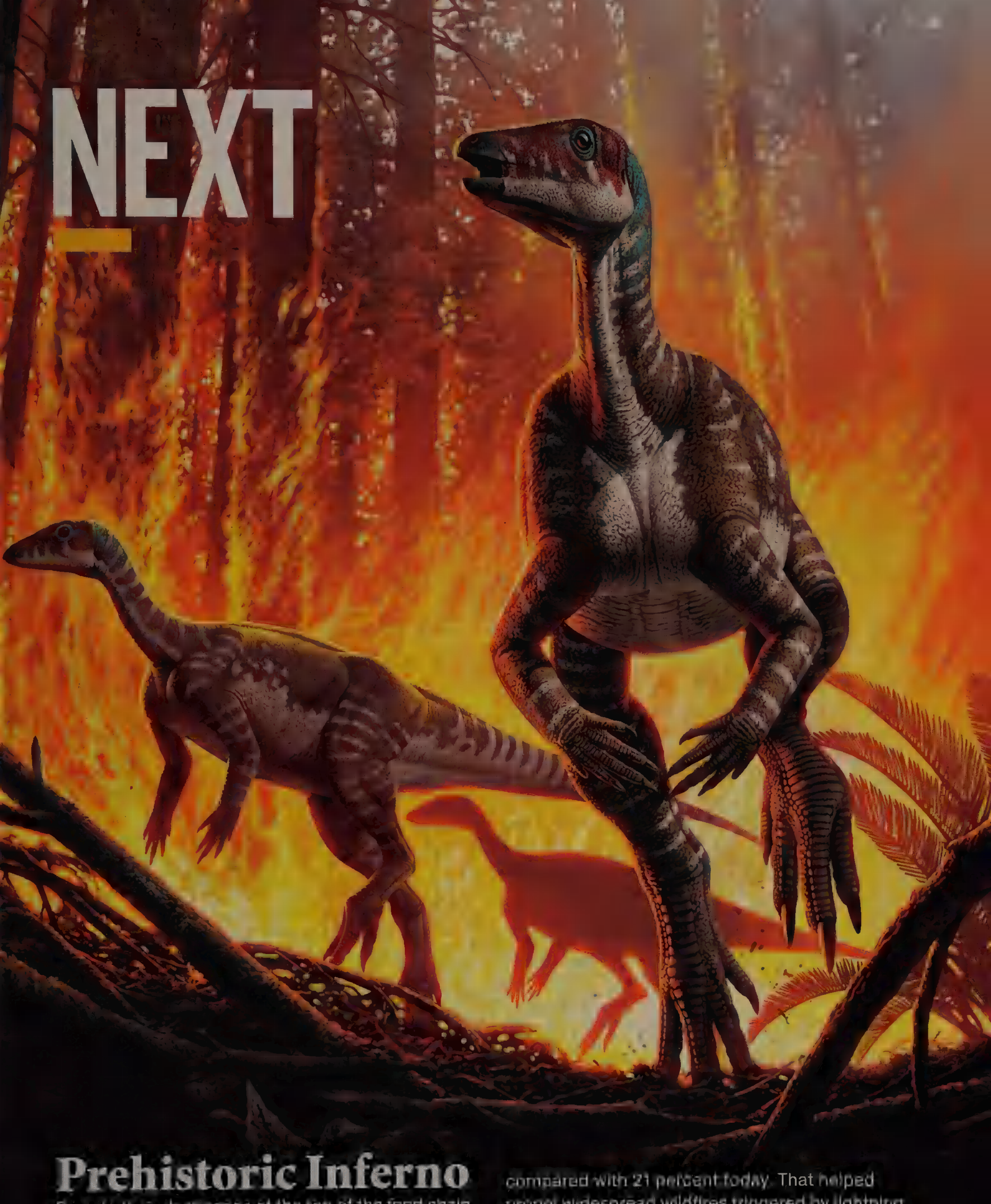


Prehistoric Inferno

Despite their dominance at the top of the food chain, dinosaurs had it rough. New research suggests that before an asteroid likely ended their lives, dinosaurs in genera like *Parksosaurus* (above) and *Psittacosaurus* and their brethren roamed a fiery planet.

Charcoal remnants from the Cretaceous period around 80 million years ago reveal that the atmosphere was loaded with oxygen—around 25 percent, compared with 21 percent today. That helped propel widespread wildfires triggered by lightning strikes, allowing even moist trees and shrubs to burn. Then, with sparse vegetation, major floods could have drowned entire regions. Paleobotanist Sarah Brown suspects that the fires were "a regular part of the dinosaurs' lifestyle," forcing mass migrations. Not to mention the stress of looking for unburned food. *—Daniel Stone*

ART: RAÚL MARTÍN

This quiz is the third of seven to run in 2013 to celebrate National Geographic's 125th anniversary. The next quiz will appear in July.

MAPPING THE WORLD

In *The Hound of the Baskervilles,* Sherlock Holmes spends a day roaming the Devonshire moors while his body somehow remains seated in an armchair, consuming "two large pots of coffee and an incredible amount of tobacco." In that spirit this quiz celebrates the magical power of maps to transport us out of our own lives and into the unknown.

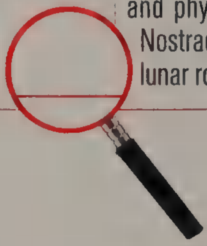
1. THE CAVE SYSTEM AT LASCAUX, FRANCE, CONTAINS WHAT MAY BE **THE WORLD'S FIRST MAPS,** DRAWN NEARLY 19,000 YEARS AGO. WHAT DO THEY DEPICT? A. Trade routes south to the Mediterranean B. The course of the Dordogne River C. The summer sky D. The route to hunting grounds

2. PRESIDENT THOMAS JEFFERSON SENT LEWIS AND CLARK UP THE **MISSOURI RIVER** TO FIND WHAT GOAL THAT MAPS HAD LONG WISHFULLY DEPICTED? A. New outposts for fur trapping B. The grazing land of buffalo C. The passage to India D. An ancient city of gold in the "Stony Mountains"

3. MASSIMO **VIGNELLI'S MAP** MADE SENSE OUT OF A TANGLE OF INFORMATION AND WAS A FAVORITE OF **GRAPHIC DESIGNERS.** BUT THE LOCALS HATED IT. WHAT DID VIGNELLI MAP? A. Tribal territories in 17th-century New England B. The corridors of the Pentagon, outside Washington, D.C. C. Rome's ancient cities of the dead D. The New York City subway system

4. **MARIE THARP** IS CELEBRATED FOR HAVING ACCURATELY MAPPED WHAT **REMOTE REGION?** A. The seas of Mars B. The Earth's ocean floor C. The Transantarctic Mountains D. The Central Siberian Plateau

5. WHO MADE THE **FIRST MAP OF THE MOON?** A. English mathematician Thomas Harriot B. Italian physicist and astronomer Galileo C. French apothecary and physician and astrologer Nostradamus D. NASA's lunar rover



6. WHAT IS THE **HUMAN CONNECTOME PROJECT** MAPPING? A. The human brain B. The human evolutionary tree C. Social networks in scientific discovery D. The lymphatic system and its role in immune function

FIND ANSWERS ON PAGE 27.

PHOTOS (FROM TOP): RYAN MCVAY, PHOTODISC/GETTY IMAGES; RICHARD KEELING; ANDY CRAWFORD, DORLING KINDERSLEY/GETTY IMAGES; D. HURST, ALAMY

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- **Celebrex is not a narcotic.**

When it comes to finding the right arthritis treatment for you, you and your doctor need to balance the benefits with the risks. So ask your doctor about prescription Celebrex. It could be an important step towards keeping *your* body in motion.

Visit **celebrex.com** or call 1-888-CELEBREX for more information.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch or call 1-800-FDA-1088.

*Individual results may vary. **Clinical studies with osteoarthritis patients.

Important Safety Information:

All prescription NSAIDs, like CELEBREX, ibuprofen, naproxen and meloxicam have the same cardiovascular warning. They may all increase the chance of heart attack or stroke, which can lead to death. This chance increases if you have heart disease or risk factors for it, such as high blood pressure or when NSAIDs are taken for long periods.

CELEBREX should not be used right before or after certain heart surgeries.

Serious skin reactions, or stomach and intestine problems such as bleeding and ulcers, can occur without warning and may cause death. Patients taking aspirin and the elderly are at increased risk for stomach bleeding and ulcers.

Tell your doctor if you have: a history of ulcers or bleeding in the stomach or intestines; high blood pressure or heart failure; or kidney or liver problems.

CELEBREX should not be taken in late pregnancy.

Life-threatening allergic reactions can occur with CELEBREX. Get help right away if you've had swelling of the face or throat or trouble breathing. Do not take it if you have bleeding in the stomach or intestine, or you've had an asthma attack, hives, or other allergies to aspirin, other NSAIDs or certain drugs called sulfonamides.

Prescription CELEBREX should be used exactly as prescribed at the lowest dose possible and for the shortest time needed.

See the Medication Guide on the next page for important information about Celebrex and other prescription NSAIDs.

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Medication Guide
for
Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)

(See the end of this Medication Guide
for a list of prescription NSAID medicines.)

What is the most important information I should know about medicines called Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)?

NSAID medicines may increase the chance of a heart attack or stroke that can lead to death.

This chance increases:

- with longer use of NSAID medicines
- in people who have heart disease

NSAID medicines should never be used right before or after a heart surgery called a "coronary artery bypass graft (CABG)."

NSAID medicines can cause ulcers and bleeding in the stomach and intestines at any time during treatment. Ulcers and bleeding:

- can happen without warning symptoms
- may cause death

The chance of a person getting an ulcer or bleeding increases with:

- taking medicines called "corticosteroids" and "anticoagulants"
- longer use
- smoking
- drinking alcohol
- older age
- having poor health

NSAID medicines should only be used:

- exactly as prescribed
- at the lowest dose possible for your treatment
- for the shortest time needed

What are Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)?

NSAID medicines are used to treat pain and redness, swelling, and heat (inflammation) from medical conditions such as:

- different types of arthritis
- menstrual cramps and other types of short-term pain

Who should not take a Non-Steroidal Anti-Inflammatory Drug (NSAID)?

Do not take an NSAID medicine:

- if you had an asthma attack, hives, or other allergic reaction with aspirin or any other NSAID medicine
- for pain right before or after heart bypass surgery

Tell your healthcare provider:

- about all of your medical conditions.
- about all of the medicines you take. NSAIDs and some other medicines can interact with each other and cause serious side effects. **Keep a list of your medicines to show to your healthcare provider and pharmacist.**
- if you are pregnant. **NSAID medicines should not be used by pregnant women late in their pregnancy.**
- if you are breastfeeding. **Talk to your doctor.**

What are the possible side effects of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)?

Serious side effects include:

- heart attack
- stroke
- high blood pressure
- heart failure from body swelling (fluid retention)
- kidney problems including kidney failure
- bleeding and ulcers in the stomach and intestine
- low red blood cells (anemia)
- life-threatening skin reactions
- life-threatening allergic reactions
- liver problems including liver failure
- asthma attacks in people who have asthma

Other side effects include:

- stomach pain
- constipation
- diarrhea
- gas
- heartburn
- nausea
- vomiting
- dizziness

Get emergency help right away if you have any of the following symptoms:

- shortness of breath or trouble breathing
- chest pain
- weakness in one part or side of your body
- slurred speech
- swelling of the face or throat

Stop your NSAID medicine and call your healthcare provider right away if you have any of the following symptoms:

- nausea
- more tired or weaker than usual
- itching
- your skin or eyes look yellow
- stomach pain
- flu-like symptoms
- vomit blood
- there is blood in your bowel movement or it is black and sticky like tar
- skin rash or blisters with fever
- unusual weight gain
- swelling of the arms and legs, hands and feet

These are not all the side effects with NSAID medicines. Talk to your healthcare provider or pharmacist for more information about NSAID medicines.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

Other information about Non-Steroidal Anti-Inflammatory Drugs (NSAIDs)

- Aspirin is an NSAID medicine but it does not increase the chance of a heart attack. Aspirin can cause bleeding in the brain, stomach, and intestines. Aspirin can also cause ulcers in the stomach and intestines.
- Some of these NSAID medicines are sold in lower doses without a prescription (over-the-counter). Talk to your healthcare provider before using over-the-counter NSAIDs for more than 10 days.

NSAID medicines that need a prescription

Generic Name	Tradename
Celecoxib	Celebrex
Diclofenac	Cataflam, Voltaren, Arthrotec (combined with misoprostol)
Diflunisal	Dolobid
Etodolac	Lodine, Lodine XL
Fenoprofen	Nalfon, Nalfon 200
Flurbiprofen	Ansaid
Ibuprofen	Motrin, Tab-Profen, Vicoprofen* (combined with hydrocodone), Combunox (combined with oxycodone)
Indomethacin	Indocin, Indocin SR, Indo-Lemmon, Indomethagan
Ketoprofen	Oruvail
Ketorolac	Toradol
Mefenamic Acid	Ponstel
Meloxicam	Mobic
Nabumetone	Relafen
Naproxen	Naprosyn, Anaprox, Anaprox DS, EC-Naproxyn, Naprelan, Naprapac (copackaged with lansoprazole)
Oxaprozin	Daypro
Piroxicam	Feldene
Sulindac	Clinoril
Tolmetin	Tolectin, Tolectin DS, Tolectin 600

* Vicoprofen contains the same dose of ibuprofen as over-the-counter (OTC) NSAIDs, and is usually used for less than 10 days to treat pain. The OTC NSAID label warns that long term continuous use may increase the risk of heart attack or stroke.

This Medication Guide has been approved by the U.S. Food and Drug Administration.
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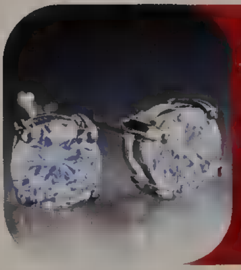

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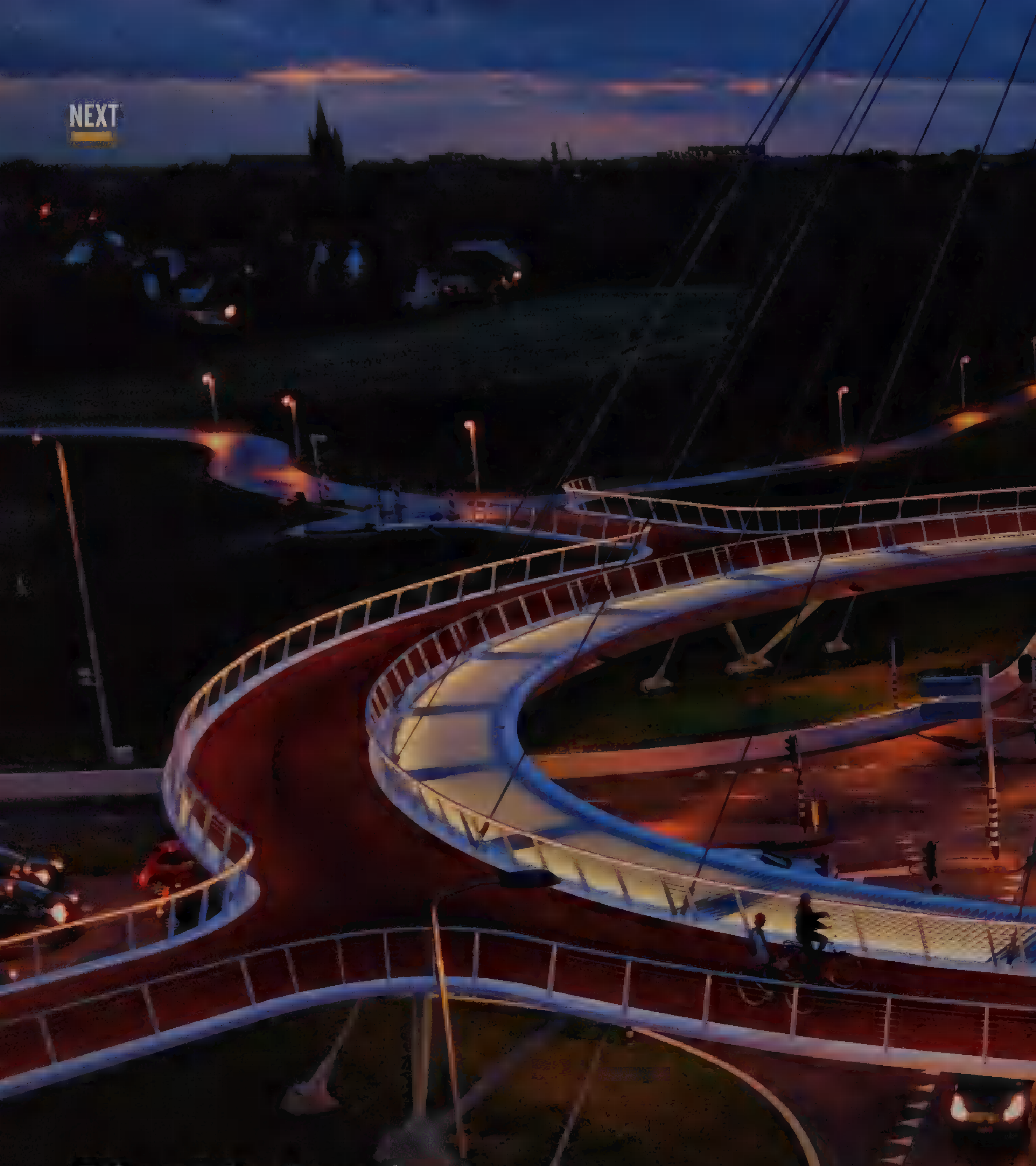


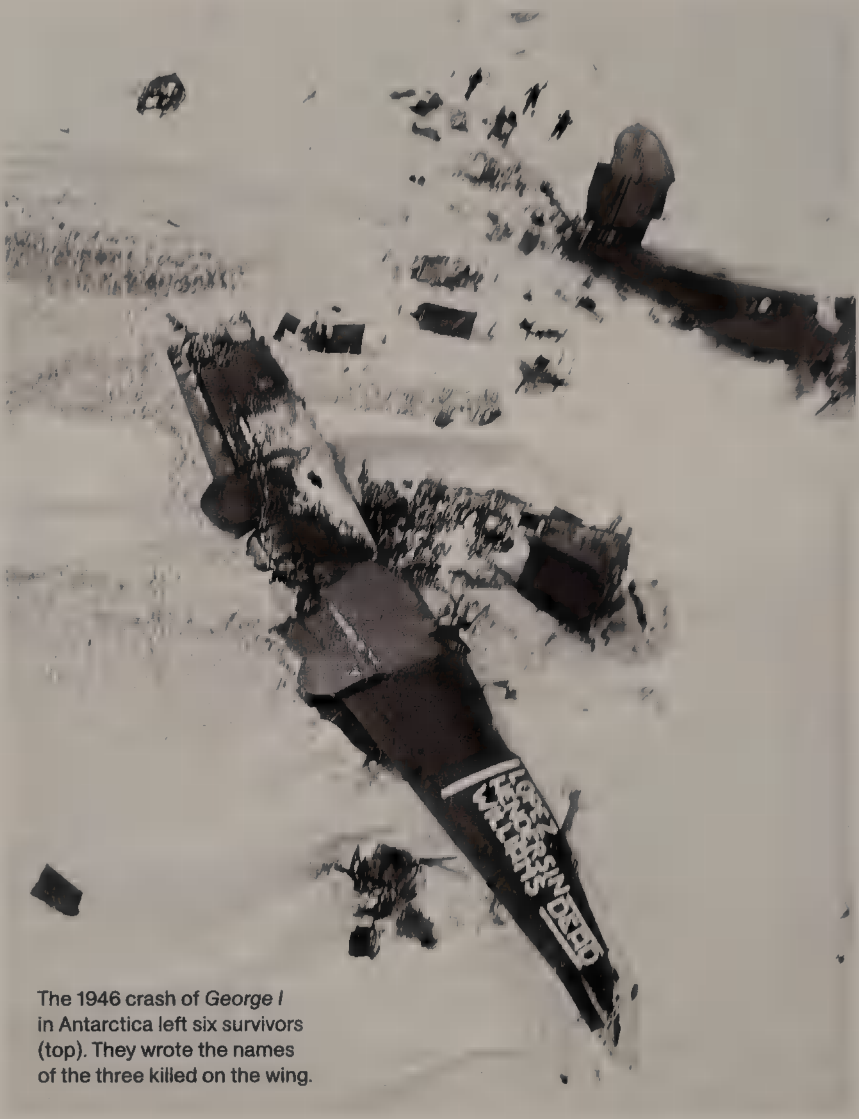
Ring Mastered

The city of Eindhoven is using circular reasoning. An elevated 360-degree bike circuit is the Netherland city's answer to traffic congestion. Pedaling is not just a pastime in the region: About one-quarter of all transportation is by bicycle. Since bikes can't go as fast as cars, they can precipitate jams, especially along the A2, the Netherlands' most traveled north-south speedway. Open since last June, the bridge gives the local population of about a quarter million the option to ride above the gas-fueled fray.

The bridge's cable design with just one central support ensures that no sides are obstructed. "Users can connect in every direction," says Adriaan Kok, one of the ring's engineers. Though it seems to hover, the ring's no pushover. Counterweights line the white inner ring to keep the structure stable, allowing locals like Peter Termeer to ride it regularly, "even though it's always windy in the Netherlands," he says. City officials estimate that 5,000 cyclists pedal on it every day, making it one of the busiest bicycle ways in the country, while 25,000 cars share the space below. Bottleneck alleviated. *—Johnna Rizzo*

KEULEN

The world's total adult population weighs in at **633 billion pounds.** That's the equivalent of nearly 3,300 *Nimitz*-class aircraft carriers.



The 1946 crash of *George I* in Antarctica left six survivors (top). They wrote the names of the three killed on the wing.

Icebound

Some of the last casualties of World War II didn't die in combat. They were part of a military mission to chart Antarctica. When the *George I* crashed while mapping Thurston Island on December 30, 1946, just a day before President Truman proclaimed hostilities officially over, six men survived. They buried three others—Maxwell Lopez, Wendell Hendersin, and Frederick Williams—under the wreckage and wrote their names on the wing.

Whether or not to recover them is at issue. The U.S. Navy considers the men properly buried. Polar recovery specialist Lou Sapienza counters that they are in a glacier, not the sea. The families, working with Sapienza and members of Congress to present a bill, want them home. Shifting ice is adding urgency. The part of Antarctica where they are entombed is about four miles closer to the water's edge now than when the plane went down. "The glacier that they're in is moving toward the Bellingshausen Sea," Sapienza says. "It will eventually calve off." *—Johnna Rizzo*

[illegible]

Record of Earth

Since 1977's launch of Voyager 1, a golden record with an "interstellar message" has been hurtling with it toward the solar system's edge. The late astronomer Carl Sagan led a team that chose earthly images and sounds to include. A cover etched with "scientific hieroglyphics," as creative director Ann Druyan puts it, indicates the craft's point of origin and how to play the message for whoever (or whatever) finds it. *—Luna Shyr*

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PLANET EARTH

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GRAPHIC: LAZARO GAMIO. SOURCE: LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

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What Stauer Clients Are Saying
About Our Hybrid Watches
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"Great watch... an
impressive piece
straight out
of the box."
— C. from
Colorado

75% Less than the independently appraised value*

$49 Colossus Watch with FREE Sunglasses!

No More Mr. Nice Watch

Forget sleek and subtle, the Stauer Colossus Hybrid is one tough timepiece...now for less than $50!

Never underestimate your competition. Just ask Demetrius, the unfortunate Greek general who set out to conquer Rhodes in 305 BC. He assumed that a massive force of 40,000 men, a fleet of Aegean pirates and an arsenal of wall-smashing war machines would be enough to crush the tiny Greek island. He was wrong. The Rhodians were tougher than he thought. And so is this watch. If you've always believed that the biggest, baddest watches had to cost big, bad money, the $49 Stauer *Colossus Hybrid Chronograph* is here to change your mind.

A monument to toughness. The people of Rhodes were ready for Demetrius and repelled his attack. To celebrate, they built the Colossus of Rhodes, a 107-foot bronze and iron giant that towered over the harbor like a ten-story trophy. It warned future invaders that "Rhodes is tougher than you think." You give the same message when you wear the Stauer *Colossus*.

The timepiece that works twice [illegible] hard. The *Colossus Hybrid Chronograph* will keep you on schedule, but it's about much more than time. The imposing case features a rotating gunmetal bezel that frames the silver, black and yellow face. You'll find a battalion of digital displays on the dial arranged behind a pair of luminescent hands and a bold yellow second hand. Powered by a precise quartz movement, the watch is doubly accurate in analog and digital mode.

The *Colossus* is packed with plenty of handy extras including a bright green EL back-light for enhanced nighttime visibility, a tachymeter along the outer dial and a full complement of alarms and split-second countdown timers. It secures with a folded steel bracelet that highlights a row of striking dark center links. It's a rugged watch that's more than ready for your daily grind.

More watch for less money. Big-name watchmakers raise their prices because they can get away with it. But Stauer wants to turn luxury on its head. We sent the *Colossus Hybrid* to an independent appraiser who works with auction houses, luxury estate sales and insurance companies. He valued the watch at $199.* We thanked him for his professional opinion and then ignored it. Because we still want you to wear it for ONLY $49.

Your satisfaction is guaranteed. Wear the Stauer *Colossus Hybrid Chronograph* for 30 days and if you are not 100% thrilled with your purchase, return it for a full refund of your purchase price. But once you get a taste of more watch for less money, it's likely you'll be back for more... and we'll be waiting.

WATCH SPECS: -Easy-to-read analog/digital modes -Back-lighting and luminescent hands - Tachymeter, countdown timers and alarms -Folded stainless steel bracelet fits a 6 3/4"–9" wrist

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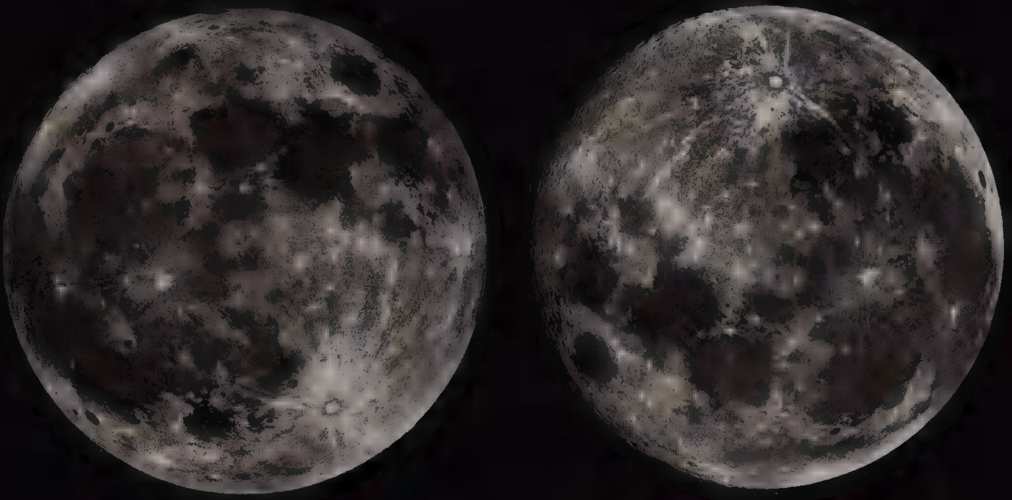
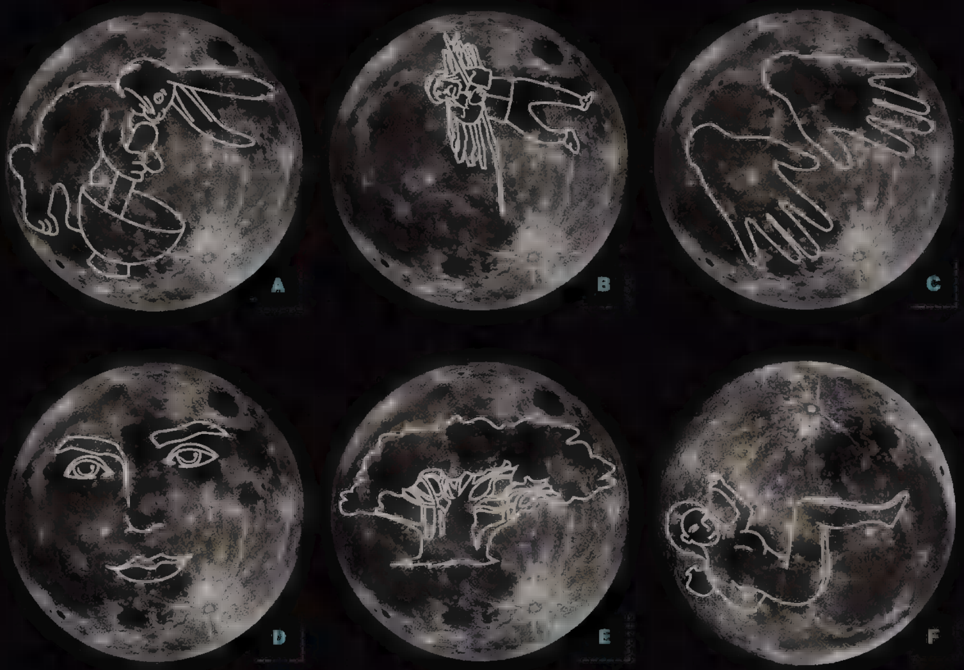


View from Northern Hemisphere

View from Southern Hemisphere



A. MOON RABBIT (EAST ASIA)
Moon gazers in Japan see a rabbit making rice cakes with a mortar and pestle. In China and Korea they see him too—except he's mixing an immortality elixir. Moon rabbits also appear in Mesoamerican myths.

B. MAN IN THE MOON (EUROPE)
Many European cultures see an old man bearing a bundle of sticks. Christian lore holds that he's been eternally condemned for violating the Sabbath.

C. HANDPRINTS (INDIA)
Astangi Mata, mother of all living things, sent her twins into the sky to be the sun and moon. Her hands brushed Chanda's cheek in a poignant farewell.

D. MAN IN THE MOON (U.S.)
The face of a man is visible to many in North America. Ancient lava flows form his eyes, nose, and mouth.

E. TREE IN THE MOON (HAWAII)
A woman called Hina uses this banyan tree to make cloth for the gods. *Mahina,* Hawaiian for "moon," is derived from her name.

F. WOMAN IN THE MOON (NEW ZEALAND)
This is Rona, a Maori maiden who disrespected the moon and must spend eternity there as penance.

Moon Faces

A mottled orb adrift in inky vastness, the full moon inspires myth and mystery, music and madness. But what you see on the face of it likely depends on where you live: Interpretations vary by region and culture.

Yet most people see something. The reason? A phenomenon called lunar pareidolia—a cosmic Rorschach test in which we perceive illusory images based on the moon's surface features. The light areas are anorthosite highlands, says planetary geologist Cassandra Runyon. The dark areas are basaltic plains forged by meteorite impacts and volcanic eruptions. When we see them, an innate form of pattern recognition—or invention—kicks in.

Now that human knack is helping NASA analyze new moon data, says the Lunar Science Institute's Brian Day. As detailed photos emerge, computers struggle to ID what they see on the variable terrain. But citizen scientists easily count craters (at *moonzoo.org* and *CosmoQuest.org*). The most pocked parts are oldest, so their tallies are key to surface dating. "Picking out patterns on the moon is a capacity we've used for eons," says Day. Only now it has a 21st-century application. —*Jeremy Berlin*

PHOTOS: PAULO CASQUINHA (NORTHERN HEMISPHERE); JOHN [illegible]
SCIENCE SOURCE/PHOTO RESEARCHERS, INC. ART: HANNAH TAK, NGM STAFF

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Nearly one in four people is a native speaker of Mandarin, Spanish, or English.

Hot Rollers

Dung beetles roll pieces of cow droppings, a core part of their diet, away from the pile to avoid feeding frenzies. Now researchers have found that some species also use the tightly packed balls to stay cool when walking across sand as hot as 150°F in South Africa. To test the beetles' heat threshold, scientists at Lund University and the University of the Witwatersrand outfitted them with boots made of heat-resistant silicon. The footwear let the insects walk on hot surfaces without pausing as often to climb atop the balls, which can be up to 77°F cooler. "These animals do amazing things on minimal computing power," says South African entomologist Marcus Byrne. The dung balls aren't just necessities. Mating beetles also use them as nuptial gifts. *–Daniel Stone*

Silicon booties helped researchers understand how some beetles use dung balls to escape hot sand.

Tattle Tailing

Reckless drivers may want to take note. Researchers in Spain are developing a system that would make every car a traffic cop. Funded by the country's Ministry of Science and Innovation, the car-to-car network could report violations to authorities. Sensors would spot nearby cars going over the limit or help lay blame for a fender bender. "Vehicles would act as witnesses of each other," says computer scientist José María de Fuentes. Knowing everyone's a snitch could make driving more stressful but also, policymakers hope, safer. *–DS*

PHOTO: ADRIAN BAILEY. ART: OLIVER MUNDAY. GRAPHIC (TOP): ÁLVARO VALIÑO
SOURCE: *ETHNOLOGUE*, 17TH EDITION, SIL INTERNATIONAL

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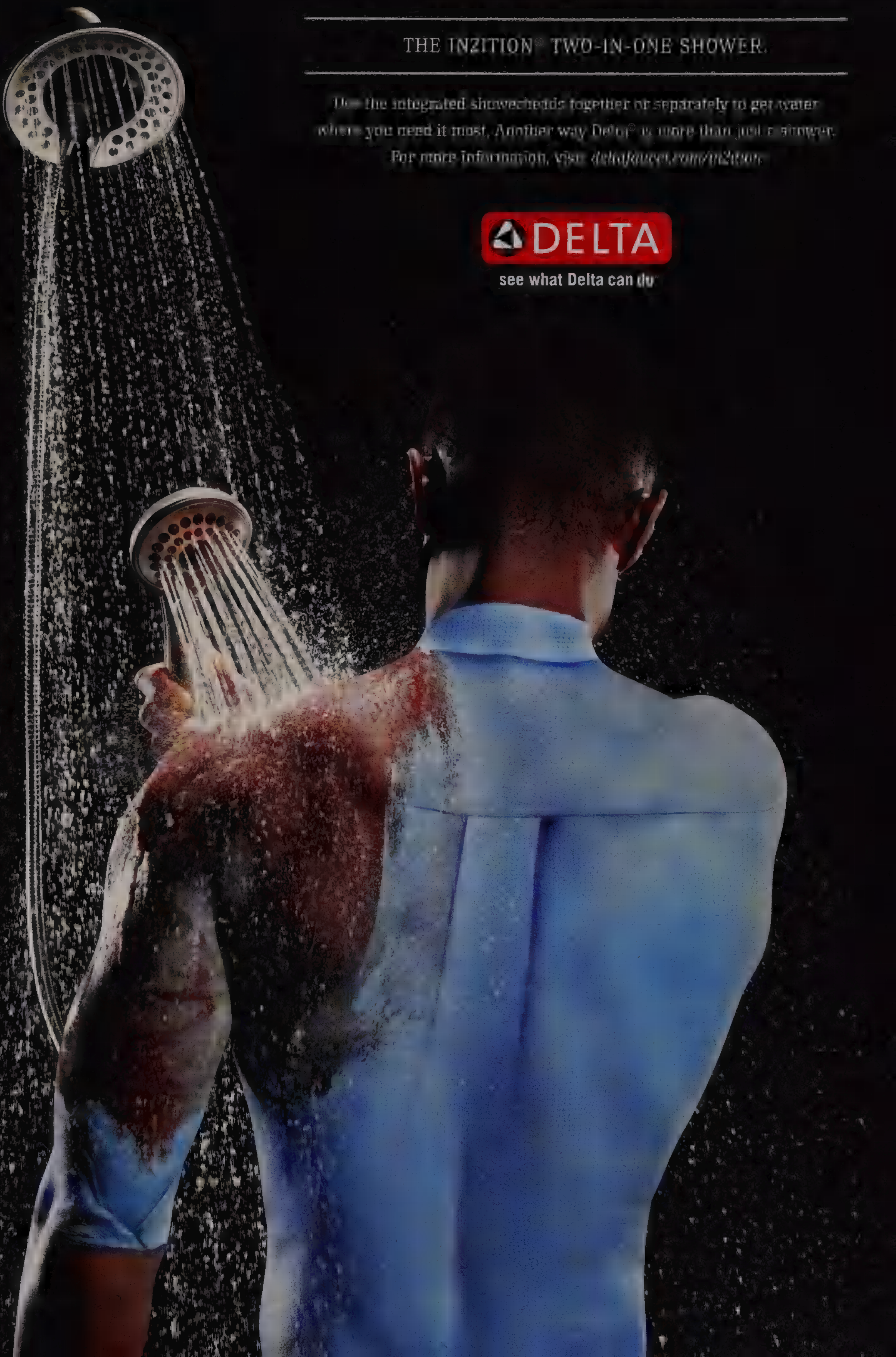


Legal Notice

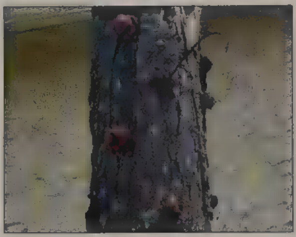
If You Had Unexplained Tree Damage After August 2010

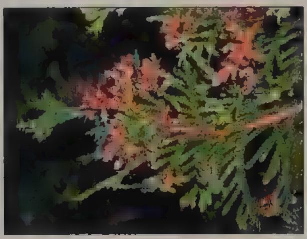
It Could Be From the Weed-Killer Imprelis®

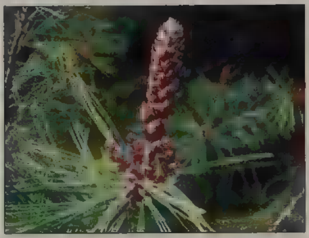
A Settlement May Provide Money and Affect Your Rights

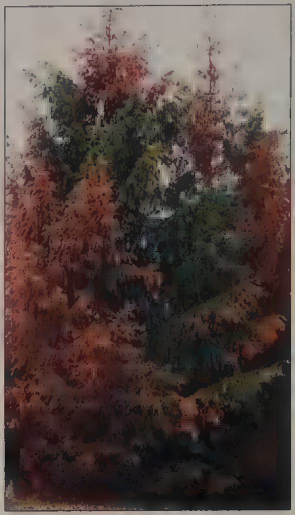
There is a class action settlement with the manufacturer of the weed-killer Imprelis®. Imprelis® was used by lawn care professionals on residential and commercial properties as well as by golf courses between August 31, 2010, and August 21, 2011, across the country — except California and New York. The lawsuit claims that Imprelis® kills and damages trees and other non-target vegetation. Imprelis® was removed from the market after reports of damaged and dying trees.

These are just a few types of Imprelis® damage.
There are more photos at www.TreeDamageSettlement.com.


Honey Locust (Fleshy galls)


Arborvitae (Browning)


Pine (Terminal Bud Swelling/Clubbing)


Spruce (Browning)

Who is Included in the Settlement and What Does the Settlement Provide?

The Settlement includes three groups, called "classes." You are included even if you have already submitted a claim through the current Imprelis® Claims Resolution Process.

Classes	Who is Included	Benefits
Class 1	*Property Owners who own or owned property in the U.S.:* 1) Where Imprelis® was applied; or 2) Adjacent to a property where Imprelis® was applied, and whose trees show damage from Imprelis® by February 11, 2013.	*Compensation for tree damage, including:* 1) Tree removal; 2)Cash payments for tree replacement and care; and 3) A limited warranty for any future Imprelis® tree damage.
Class 2	*Applicators (Lawn Care Professionals) that:* 1) Purchased Imprelis® or received Imprelis® from a purchaser; and 2) Applied Imprelis® on property owned by another person or entity in the U.S. as part of their normal business.	*Compensation for:* 1) Customer site visits, field work, and expenses incurred in investigating and documenting Imprelis® damage on customers' properties prior to September 6, 2011; 2) Refund for returning unused Imprelis®; and 3) Assisting their customers with the Settlement Claims Process, if applicable.
Class 3	*Golf Courses and Other Imprelis® Self-Applicators that:* 1) Purchased Imprelis® or received Imprelis® from a purchaser; and 2) Applied Imprelis® on property in the U.S. that they own or owned.	*Compensation for:* 1) Tree damage as listed above for Class 1; 2) Time spent and expenses incurred in assessing Imprelis® damage; and 3) Refund for returning unused Imprelis®.

What are my Legal Rights?

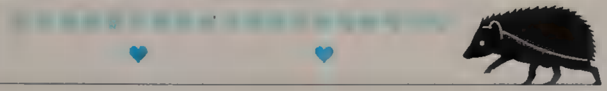
To get information on how to claim benefits from the settlement, visit the website or call the toll free number listed below. To keep your right to sue about Imprelis® damage, you must exclude yourself in writing by June 28, 2013. If you ask to be excluded, you cannot get the Settlement benefits. If you stay in the Settlement, you may object to it in writing by August 21, 2013. If you stay in the Settlement, you will be bound by the Court's orders.

The Court will hold a hearing on September 27, 2013 to consider whether to approve the Settlement and a request by Class Counsel for attorneys' fees and expenses of up to $7 million. You or your own lawyer may ask to appear and speak at the hearing at your cost.

If you have Imprelis® damage, your rights are affected whether you act or not. Get more information using the contact information below.

www.TreeDamageSettlement.com 1-866-802-8112 Text "Tree" to 96000

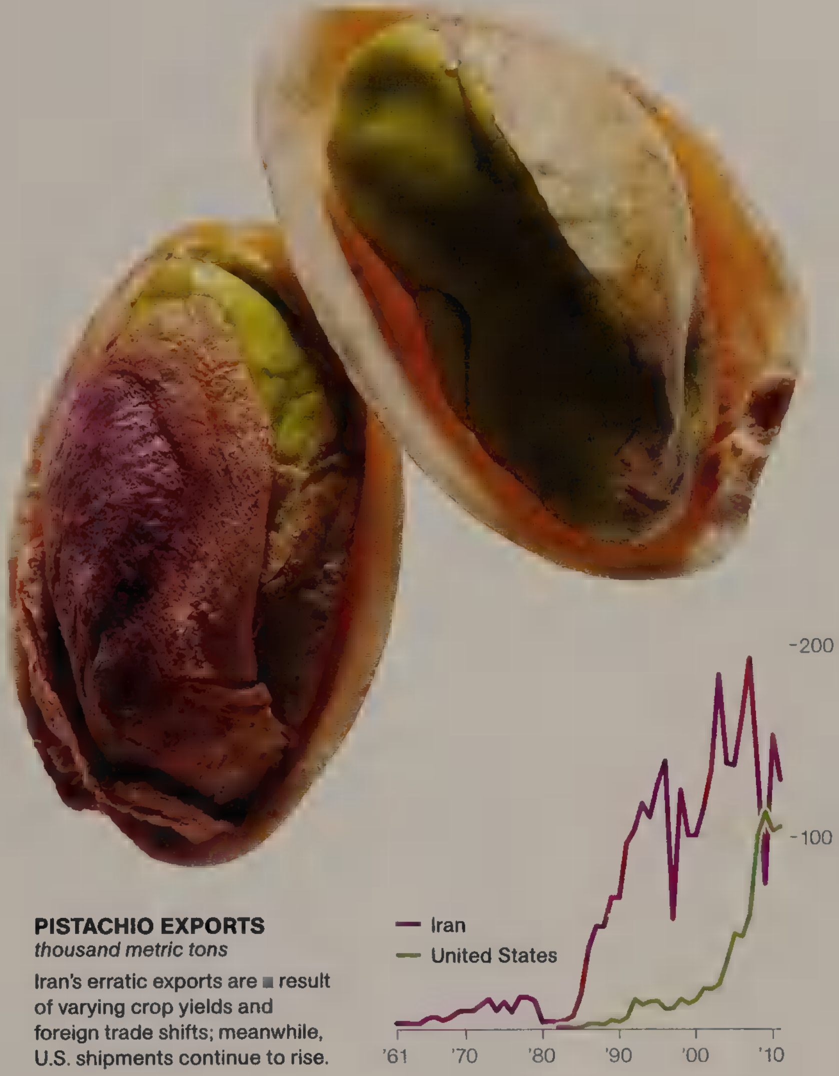
A hedgehog's heart rate goes from 190 beats per minute to 20 when hibernating.



Going Nuts

People want pistachios. Native to the Middle East, the heart-healthy nut has gone global, especially over the past decade, as consumption rose more than 50 percent. Iran has long dominated the market, but when a 2008 frost ravaged its crop, farmers in fertile California saw a chance to meet rising demand.

Politics also play a role. As sanctions have squeezed Iranian exports for 30 years, America has ramped up production, to a new high last year, according to the USDA. "The impact was pronounced when U.S. farmers planted in the '70s and '80s," says the American Pistachio Growers' Richard Matoian. Concerns over Iran's nuclear program mean places like western Europe, China, and Israel—which cracks open the most pistachios per capita—are looking more to the U.S. to feed their appetites. *—Catherine Zuckerman*



PISTACHIO EXPORTS
thousand metric tons

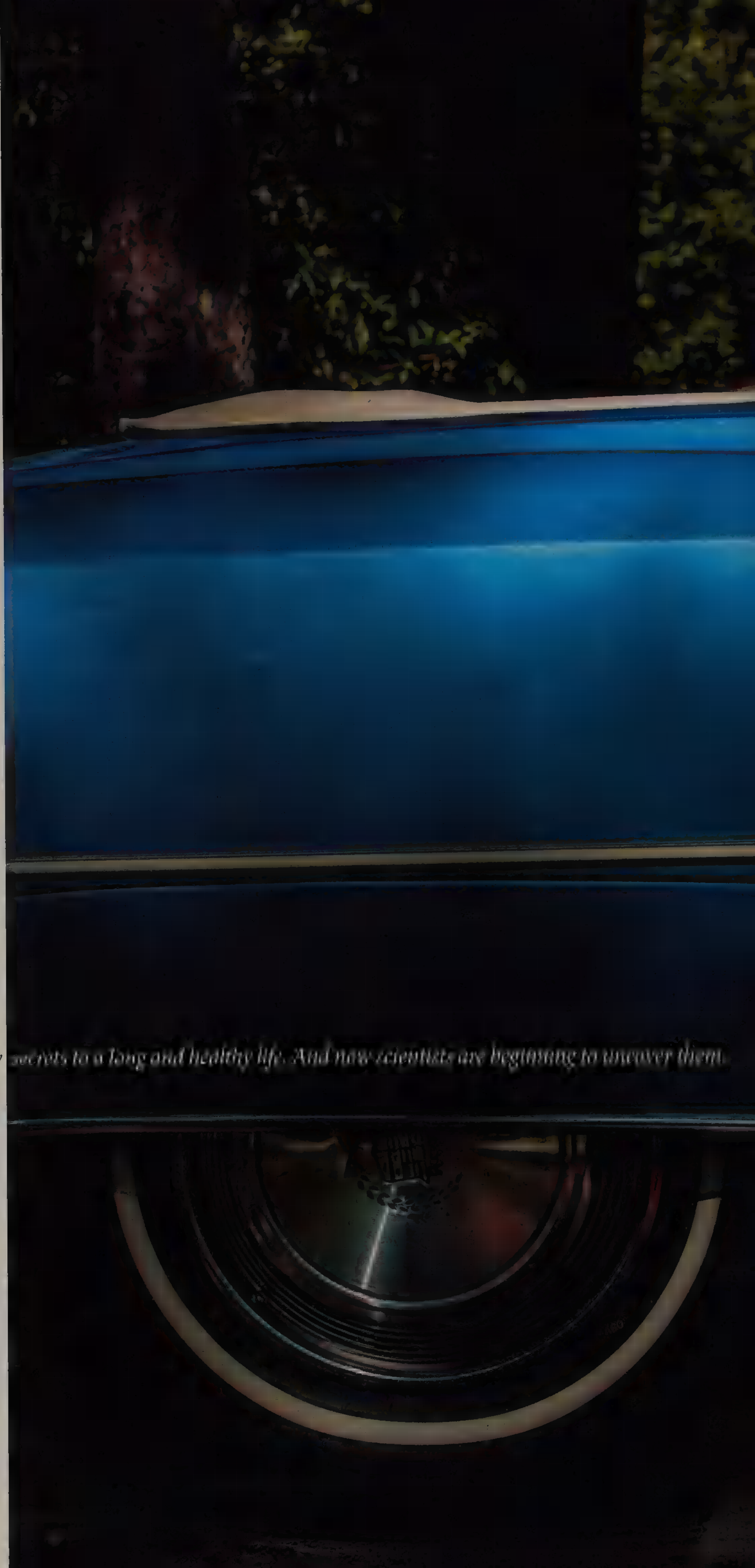
Iran's erratic exports are a result of varying crop yields and foreign trade shifts; meanwhile, U.S. shipments continue to rise.

ANSWERS FOR EXPLORERS QUIZ

1. (C) The summer sky. Studying animals painted on the cave walls, German researcher Michael Rappenglück recognized that their eyes indicated the positions of three of the most prominent stars in the summer sky: Vega, Deneb, and Altair. The cave system may also contain a drawing of the Pleiades star cluster.
2. (C) The passage to India. Contemporary maps hinted of a relatively easy water route through the so-called Stony Mountains, perhaps joining up with the recently discovered Columbia River. The expedition's hopes for a Northwest Passage came to an end at the headwaters of the Missouri, high in the Rocky Mountains.
3. (D) The New York City transit system introduced Vignelli's new map of the subway system in 1972. Working on the model of Harry Beck's 1933 London Underground map, Vignelli emphasized simplicity of design at the expense of geographic detail. New Yorkers responded with kvetching. ("The verbal people, they can never read a map," Vignelli later said, but "they can be heard.") His map is now in the Museum of Modern Art collection, not in the subways.
4. (B) The Earth's ocean floor. In 1948, at age 28, Tharp got a job in Columbia University's male-dominated geology department. She took on the task of translating sonar readings from ocean expeditions into detailed maps of the seafloor, representing 70 percent of Earth's surface. The 1977 "World Ocean Floor" map by Tharp and colleague Bruce Heezen is still used. Their work also provided crucial evidence of continental drift and plate tectonics, which had been geological heresy. In 2009 Google Earth introduced maps enabling anyone to explore the ocean floor by computer; essential details came from the hands of Tharp and Heezen.
5. (A) English mathematician Thomas Harriot focused on the moon with his new telescope in the summer of 1609 and sketched what he saw. He thus became the first to map an astronomical object after viewing it through a telescope. He improved his remarkably accurate moon maps over the years but never published them.
6. (A) The human brain. Advances in imaging technology are making it easier to create maps, or "connectomes," of the human brain, and in 2010 the National Institutes of Health began funding the five-year, $40 million Human Connectome Project. By mapping how the brain's billions of neurons work together, researchers hope to get a better understanding of how we think and feel.

PHOTO: REBECCA HALE, NGM STAFF. NGM ART. SOURCE: FAOSTAT
GRAPHIC (TOP): ÁLVARO VALIÑO. SOURCE: BRITISH HEDGEHOG PRESERVATION SOCIETY

Our genes harbor many secrets to a long and healthy life. And now scientists are beginning to uncover them.



JOHN G.
TALCOTT, JR.

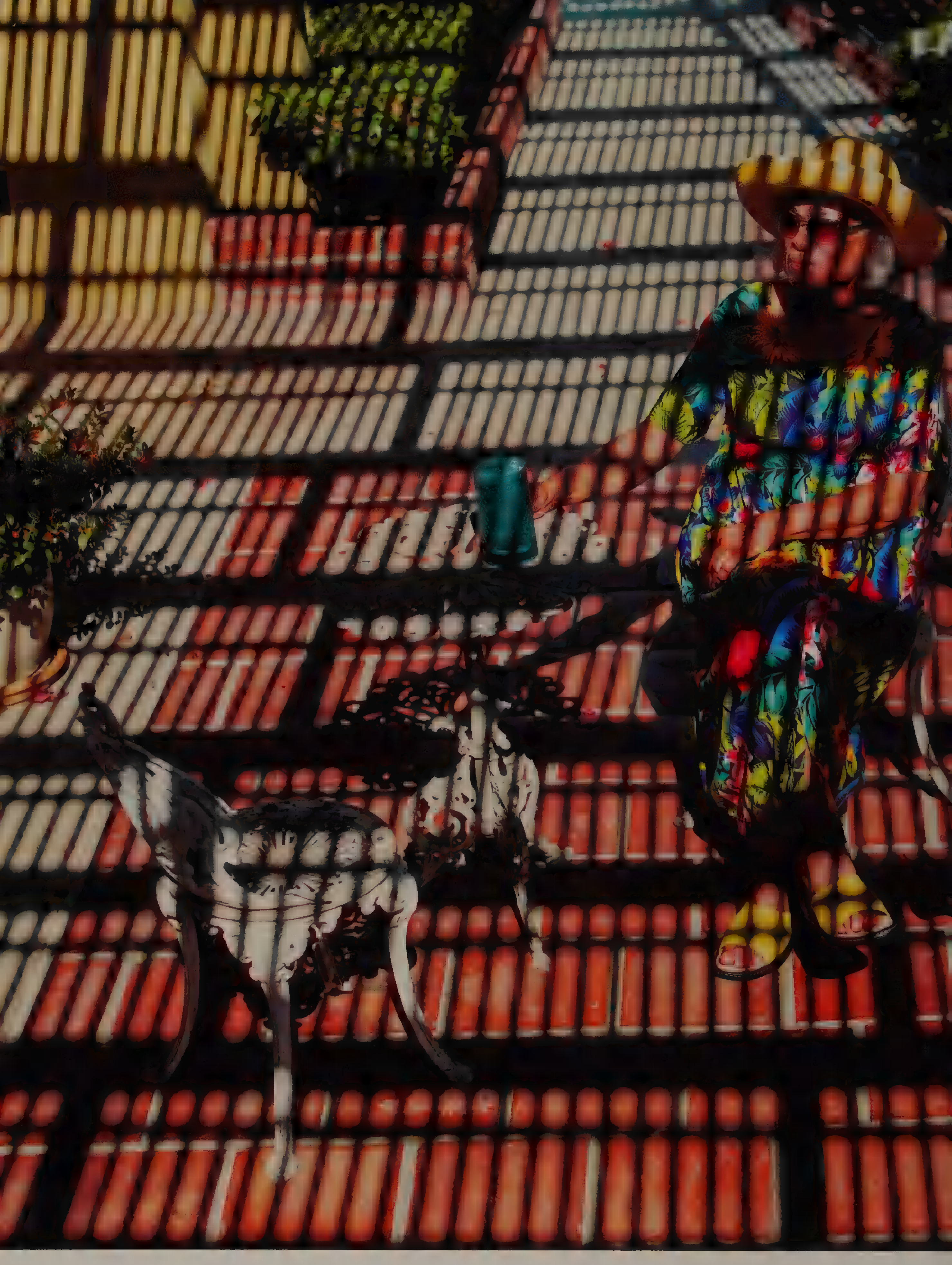
104

Looking sharp in his World War II Army uniform and Cadillac convertible, Talcott serves as marshal of the Fourth of July parade in Plymouth, Massachusetts.

ON BEYOND 100

BY STEPHEN S. HALL

PHOTOGRAPHS BY FRITZ HOFFMANN



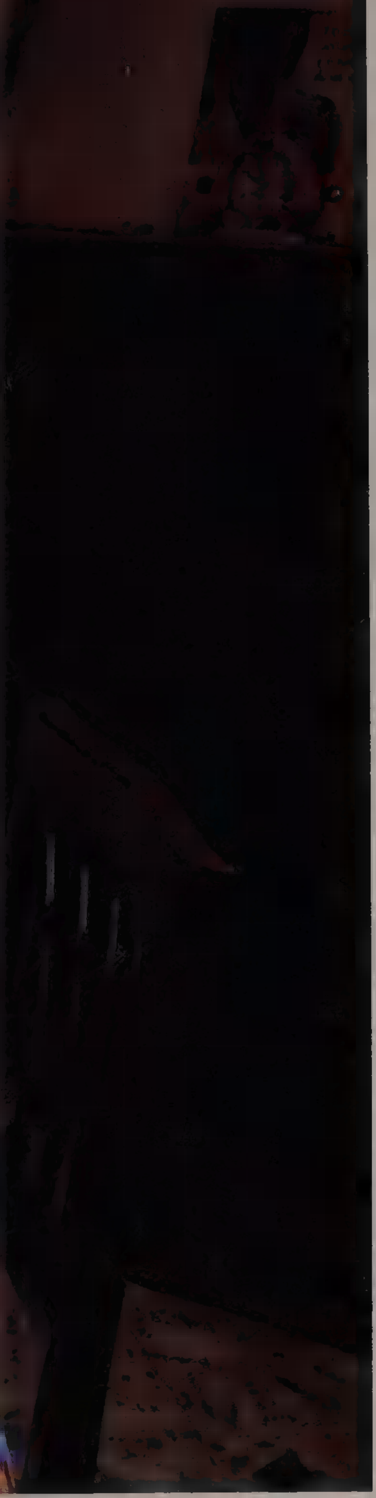
RUBY TIMMS

85

The oldest of eight, Timms grew up "beyond poor" on a farm in Longview, Texas, where she helped her widowed mother cook and care for her brothers and sisters. Now widowed herself, Timms still lives in the San Diego house that she and her husband moved to in 1965. She relaxes under the patio lattice adjacent to the rose garden, where she likes to work first thing every day.

"My mother used to say, 'If you live to be 70, that's all God promised you.'"

On a crisp January morning, with snow topping the distant Aspromonte mountains and oranges ripening on the nearby trees, Giuseppe Passarino guided his silver minivan up a curving mountain road into the hinterlands of Calabria, mainland Italy's southernmost region. As the road climbed through fruit and olive groves, Passarino, a geneticist at the University of Calabria, chatted with his colleague Maurizio Berardelli,



GIUSEPPE ROMEO

101

Romeo lives in San Fili, Italy. He makes his own pasta and knows how to massage away his own aches and pains—skills he perfected as a prisoner of war after he was captured by the British during World War II. The centenarian also enjoys whittling.

a geriatrician. They were headed for the small village of Molochio, which had the distinction of numbering four centenarians—and four 99-year-olds—among its 2,000 inhabitants.

Soon after, they found Salvatore Caruso warming his 106-year-old bones in front of a roaring fire in his home on the outskirts of the town. Known in local dialect as "U' Raggiuneri," the Accountant, Caruso was calmly reading an article about the end of the world in an Italian version of a supermarket tabloid. A framed copy of his birth record, dated November 2, 1905, stood on the fireplace mantle.

Caruso told the researchers he was in good health, and his memory seemed prodigiously intact. He recalled the death of his father in 1913, when Salvatore was a schoolboy; how his mother and brother had nearly died during the great influenza pandemic of 1918-19; how he'd been dismissed from his army unit in 1925 after accidentally falling and breaking his leg in two places. When Berardelli leaned forward and asked Caruso how he had achieved his remarkable longevity, the centenarian said with an impish smile, "*No Bacco, no tabacco, no Venere*—No drinking, no smoking, no women." He added that he'd eaten mostly figs and beans while growing up and hardly ever any red meat.

Passarino and Berardelli heard much the same story from 103-year-old Domenico Romeo—who described his diet as "*poco, ma tutto;* a little bit, but of everything"—and 104-year-old Maria Rosa Caruso, who, despite failing health, regaled her visitors with a lively version of a song about the local patron saint.

On the ride back to the laboratory in Cosenza, Berardelli remarked, "They often say they prefer to eat only fruits and vegetables."

"They preferred fruit and vegetables," Passarino said drily, "because that's all they had."

Although eating sparingly may have been less a choice than an involuntary circumstance of poverty in places like early 20th-century Calabria, decades of research have suggested that a severely restricted diet is connected to long life. Lately, however, this theory has fallen on hard scientific times. Several recent studies have undermined the link between longevity and caloric restriction.

In any case, Passarino was more interested in the centenarians themselves than in what they had eaten during their lifetimes. In a field historically marred by exaggerated claims and dubious entrepreneurs hawking unproven elixirs, scientists studying longevity have begun using powerful genomic technologies, basic molecular research, and, most important, data on small, genetically isolated communities

NORMAN APOLO RAMIREZ

51

Apolo has Laron syndrome, a genetic condition that brings short stature but a chance at a long life. Those with the syndrome have a reduced risk of cancer and diabetes. A former journalist and political chief of his village of Balsas in Ecuador's El Oro Province, Apolo currently teaches high school. He is surrounded by his wife, three daughters, and infant grandson, none of whom have Laron.

"I am fortunate, fortunate for having such a lovely family. They give me life."

of people to gain increased insight into the maladies of old age and how they might be avoided. In Calabria, Ecuador, Hawaii, and even in the Bronx, studies are turning up molecules and chemical pathways that may ultimately help everyone reach an advanced age in good, even vibrant, health.

THE QUEST FOR GENETIC answers has brought international scientific attention to people like Nicolas Añazco, known as "Pajarito," Little Bird in Spanish.

In many ways Little Bird is a typical teen. He plays computer games and soccer and has been known to sneak a glance at the pinup calendar that resides beside a framed picture of the Last Supper on the dining room wall of his family's four-room home in the rural uplands of Ecuador's El Oro Province. In this steep and rugged, yet oddly lush, landscape at the foot of the Andes—with a hint of Shangri-La in its exotic mix of bananas, cauliflower, and tamarillo—the young man helps his father process the sugarcane that surrounds the house.

Little Bird, 17, said he became grudgingly aware of the reason for his nickname at age six, when he looked around at his classmates: "I realized that I was going to be smaller than them." Much smaller.

Because of a recessive mutation in a single gene, Little Bird looks like an eight-year-old and is three feet nine inches tall—much shorter than his brother Ricardo, who is a year older. The mutation causes a disease of impaired growth called Laron syndrome. But it may also protect Little Bird from serious diseases that typically ravage humans as they age. And even in this area of geographical isolation and historical poverty, word of that has gotten around.

One afternoon Little Bird and three other Laron syndrome men from the region held court for an interview at the back of an appliance store, their feet dangling in child's-size shoes from their chairs. Freddy Salazar, 39 years old and three feet ten inches tall, had recently had his 1997 Chevy Forsa retrofitted with elevated pedals and a raised seat so he could see through the windshield to negotiate his town's steep hills. Victor Rivera, 23 years old and slightly taller than Salazar, was the subject of a famous photograph, shown at many scientific meetings, taken when he was four—so small that the ear of corn he was holding was a little larger than his arm. Luis Sanchez, at 43 an elder statesman among the group, threw back his head in laughter, which was joined by the others' high-pitched voices, when someone asked if they were aware of the latest scientific reports about their condition.

"We are laughing," he explained, "because we know we are immune to cancer and diabetes."

That somewhat overstates the scientific results to date but reflects a growing interest among researchers to interrogate the genomes of unusually healthy or long-lived groups of people, whose isolation, geographical or cultural, makes it easier to find genetic clues to longevity, disease resistance, and good health at an advanced age.

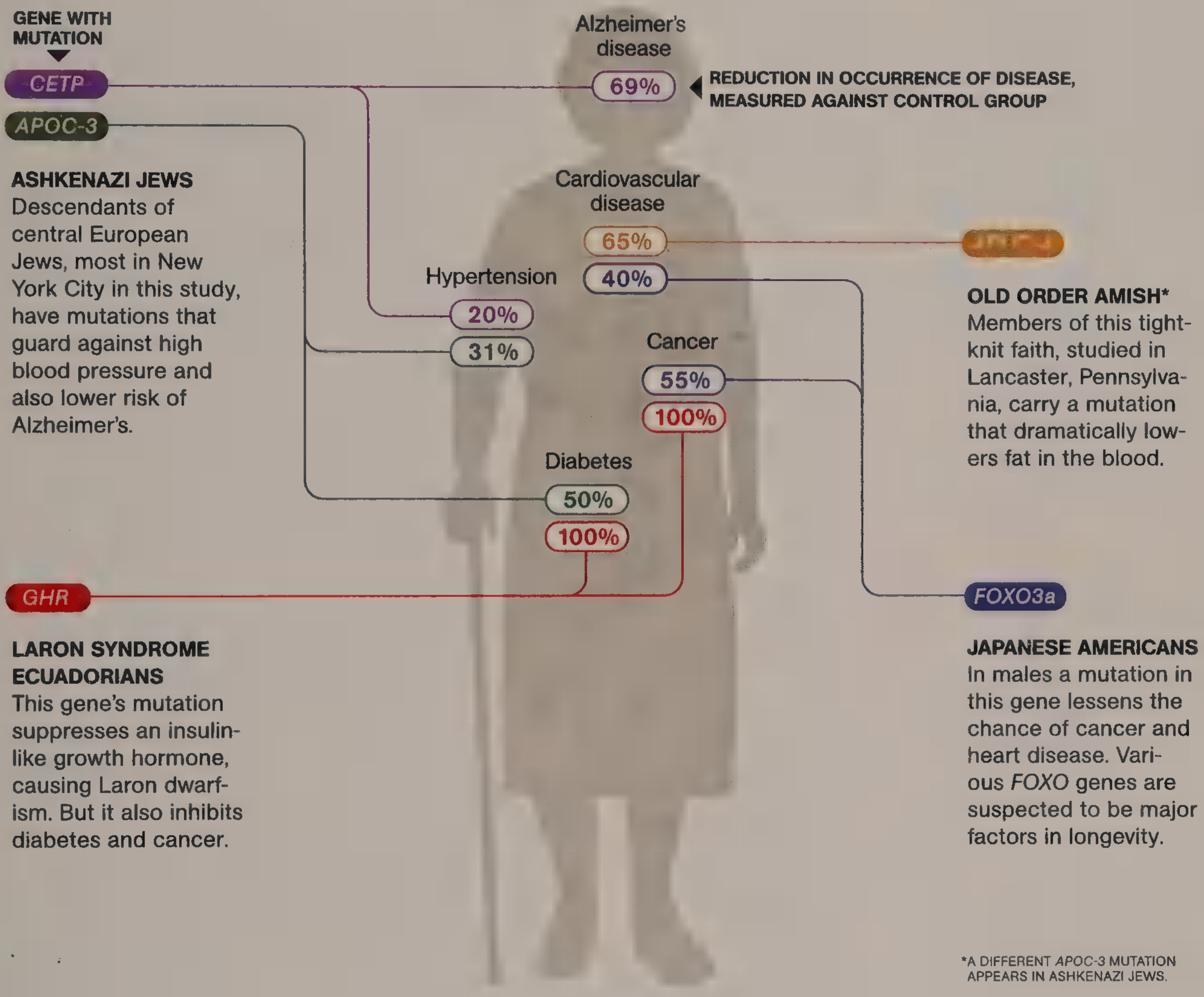
One such scientist is Little Bird's physician, Jaime Guevara, who was born in El Oro Province. Fascinated by the region's "little people," as they have been known since before their condition even had a name, he began to study them around 1987, and during a quarter century of epidemiological sleuthing he identified about a hundred people with the Laron mutation sprinkled through the hills of southern Ecuador.

Meche Romero Robles, a 40-year-old single mother, is also one of Guevara's patients. Just over four feet tall, Robles lives with her teenage daughter, Samantha, in a cinder-block, metal-roofed home perched on a hillside in the town of Piñas. "Look at her!" Guevara cried, giving the elder Robles an affectionate hug. "She should have diabetes. Given her body mass index, she must have diabetes. But she doesn't." Even to a nonmedical eye, Meche appeared obese. Like so many little people, however, she remained free of diabetes. "I realized this in 1994," Guevara said, "but no one would believe me."

Science writer Stephen S. Hall's six books include Merchants of Immortality. *For our March 2012 issue, Fritz Hoffmann photographed glacial rocks.*

Genetic clues to long life

Scientists studying groups of people genetically isolated by location or culture have found gene mutations that seem to prevent the diseases that most often shorten life. The mutations aren't limited to these groups, and not all group members have them. Learning how these genes work could help extend life for us all.



ASHKENAZI JEWS
Descendants of central European Jews, most in New York City in this study, have mutations that guard against high blood pressure and also lower risk of Alzheimer's.

OLD ORDER AMISH*
Members of this tight-knit faith, studied in Lancaster, Pennsylvania, carry a mutation that dramatically lowers fat in the blood.

LARON SYNDROME ECUADORIANS
This gene's mutation suppresses an insulin-like growth hormone, causing Laron dwarfism. But it also inhibits diabetes and cancer.

JAPANESE AMERICANS
In males a mutation in this gene lessens the chance of cancer and heart disease. Various *FOXO* genes are suspected to be major factors in longevity.

*A DIFFERENT *APOC-3* MUTATION APPEARS IN ASHKENAZI JEWS.

That began to change in 2005, when Valter Longo, a cell biologist at the University of Southern California who studies aging, invited Guevara to USC to describe his research. A decade earlier Longo had begun to manipulate the genes of simple organisms like single-celled yeast, creating mutations that allowed them to live longer. The reasons for this varied. Some mutants could repair their DNA more effectively than normal cells; others demonstrated a heightened ability to minimize the damage from oxidants. Still others became better able to derail the type of DNA damage that would promote cancer in humans.

Others were studying the same processes. In 1996 Andrzej Bartke, a scientist at Southern Illinois University, tinkered with mouse genes that are involved with growth. He showed—not surprisingly—that shutting down the growth hormone pathway resulted in smaller mice.

JOHN TOMANIO AND MATTHEW TWOMBLY, NGM STAFF; MEGAN CASSIDY. SOURCE: NIR BARZILAI, INSTITUTE FOR AGING RESEARCH, LONGEVITY GENES PROJECT, ALBERT EINSTEIN COLLEGE OF MEDICINE

SADIE MINTZ

105

As a girl, Mintz helped her parents in the store they ran from their Seattle home. As an adult, she owned a tiny jewelry shop in Hollywood, paying rent to movie star Mary Pickford for a time and once renting earrings to Marilyn Monroe for a Life *magazine photo shoot. At 104, Mintz self-published a short story. She's decked out to celebrate the Jewish New Year at the Santa Monica home of one of her three granddaughters.*

"You can't do anything at all without knowing that one word: courage."

IRVING KAHN
106

Irving Kahn began his career in finance in 1928. He is still chairman of the New York City investment advisory and brokerage firm that bears the family name. Working five hours a day, he has been called the world's oldest active investment professional.

What was surprising was that they lived longer—about 40 percent longer—than normal mice.

Could similar processes be at work in humans? Could genetic anomalies protect against diseases of age? Zvi Laron, the Israeli endocrinologist who in 1966 first described the dwarfism that came to be named after him, had found dozens of people scattered through central and eastern Europe with the rare syndrome. Longo thought Guevara's patients might represent an experiment of nature—an isolated population with a condition that linked genetics to longevity.

THE ECUADORIAN LARON PEOPLE can be traced, researchers believe, back to the late 15th century, when Jews traveled from the Iberian Peninsula to the New World with a very specific piece of baggage: a genetic misspelling known as the E180 mutation in the growth hormone receptor gene, which produces the molecule that receives the body's growth signals. This distinctive misspelling in the genetic code has also turned up in Israel.

"The presumption is that Sephardic Jews were desperate to leave Spain and Portugal because of the Inquisition," says Harry Ostrer, a medical geneticist at Albert Einstein College of Medicine in New York City who has collaborated with Guevara. "They went to North Africa, the Middle East, southern Europe. Many ventured to the New World as well, but the Inquisition followed them. So it was in their interest to get out of cities like Lima and Quito, where the church maintained its strongest presence."

They settled in small towns and villages sprinkled across 75 square miles of rural Ecuador, where until the 1980s there were few roads, no phones, and no electricity. Over the centuries the

LILLY PORT
99

"I could have been put away in a concentration camp, and nobody would have known the difference," says Port, who fled her native Vienna after the Nazis took over. The retired consumer advocate lives in New York but loves to travel, most recently to Machu Picchu.

mutation lurked and spread in the population, amplified by isolation and inbreeding. "Theoretically we are all from the same family," says Christian Asanza Reyes, an economist in Balsas, whose tall frame belies the mutation he and his wife passed on to two of their three children.

Guevara and Longo began to collaborate in 2006. Guevara had found a homogeneous group in one geographic location with a known genetic mutation that seemed to block the development of diabetes and cancer in individuals. Within the Laron group there were no cases of diabetes and only a single, nonlethal malignancy. In a control group of people the same age living in the same area, Guevara and Longo found that 5 percent developed diabetes and 20 percent died of cancer. Follow-up experiments conducted by Longo at USC showed that blood taken from the Ecuadorian patients seemed to protect human cells from laboratory-induced cancers. What was the magic ingredient in their blood?

"Nothing," Longo says.

Nothing? In fact, it was the absence of something—a hormone known as IGF-1, or insulin-like growth factor. The blood was protective, Longo says, because it had unusually low levels of IGF-1, which plays an important role in childhood growth but has also been implicated as an accelerant of cancers and as a powerful regulator of metabolism. Could controlling the presence of one hormone in human blood postpone the diseases of old age? It's probably not quite that simple, but the insulin–IGF-1 connection keeps popping up in longevity research.

IN CALABRIA the hunt for hidden molecules and mechanisms that confer longevity on people like Salvatore Caruso begins in

RAE KLINE
83

"A perpetual motion machine" is how Kline, of Solana Beach, California, describes herself. An early advocate of yoga in the U.S., she demonstrates a knees-to-ears pose. Her daily exercise includes a mile swim, an hour of biking, and a four-mile beach walk.

places like the Ufficio Anagrafe Stato Civile (Civil Registry Office) in the medieval village of Luzzi. The office windows here offer stunning views of snow-covered mountains to the north, but to a population geneticist the truly breathtaking sights are hidden inside the tall file cabinets ringing the room and on shelf after shelf of precious ledgers numbered by year, starting in 1866. Despite its well-earned reputation for chaos and disorganization, the Italian government, shortly after the unification of the country in 1861, ordered local officials to record the birth, marriage, and death of every citizen in each *comune,* or township.

Since 1994 scientists at the University of Calabria have combed through these records in every one of Calabria's 409 *comuni* to compile an extraordinary survey. Coupling family histories with simple physiological measurements of frailty and the latest genomic technologies, they set out to address fundamental questions about longevity. How much of it is determined by genetics? How much by the environment? And how do these factors interact to promote longevity—or, conversely, to hasten the aging process? To answer all those questions, scientists must start with rock-solid demographic data.

"Here is the book from 1905," explained Marco Giordano, one of Giuseppe Passarino's young colleagues, opening a tall, green ledger. He pointed to a record, in careful cursive, of the birth of Francesco D'Amato on March 3, 1905. "He died in 2007," Giordano noted, describing D'Amato as the central figure, or proband, of an extensive genealogical tree. "We can reconstruct the pedigrees of families from these records."

Cross-checking the ledger entries against meticulously detailed registry cards (pink for women, white for men) going back to the 19th century, Giordano, along with researchers Alberto Montesanto and Cinzia Martino, has reconstructed extensive family trees of 202 nonagenarians and centenarians in Calabria. The records document not only siblings of people who lived to 100 but also the spouses of siblings, which has allowed Passarino's group to do a kind of historical experiment on longevity. "We compared the ages of D'Amato's brothers and sisters to the ages of their spouses," Giordano explained. "So they had the same environment. They ate the same food. They used the same medicines. They came from the same culture. But they did not have the same genes." In a 2011 paper the Calabrian researchers reported a surprising conclusion: Although the parents and siblings of people who lived to at least 90 also lived longer than the general population, a finding in line with earlier research, the genetic factors involved seemed to benefit males more than females.

The Calabrian results on gender offer yet another hint that the genetic twists and turns that confer longevity may be unusually complex. Major European studies had previously reported that women are much likelier to live to 100, outnumbering male centenarians by a ratio of four or five to one, with the implication that some of the reasons are genetic. But by teasing out details from family trees, the Calabrian researchers discovered an intriguing paradox: The genetic component of longevity appears to be stronger in males—but women may take better advantage of external factors such as diet and medical care than men do.

In the dimly lit, chilly hallway outside Passarino's university office stand several freezers full of tubes containing centenarian blood. The DNA from this blood and other tissue samples has revealed additional information about the Calabrian group. For example, people who live into their 90s and beyond tend to possess a particular version, or allele, of a gene important to taste and digestion. This allele not only gives people a taste for bitter foods like broccoli and field greens, which are typically rich in compounds known as polyphenols that promote cellular health, but also allows cells in the intestine to extract nutrients more efficiently from food as it's being digested.

Passarino has also found in his centenarians a revved-up version of a gene for what is called an uncoupling protein. The protein plays a central role in metabolism—the way a person consumes energy and regulates body heat—which in turn affects the rate of aging.

"We have dissected five or six pathways that most influence longevity," says Passarino. "Most of them involve the response to stress, the metabolism of nutrients, or metabolism in general—the storage and use of energy." His group is currently examining how environmental influences—everything from childhood diet to how long a person attends school—might modify the activity of genes in a way that either promotes or curtails longevity.

ANOTHER CONTINENT, another genetic island. It was a gray day in the Bronx, and 81-year-old Jean Sisinni paced back and forth on a gray carpet in a third-floor room on Morris Park Avenue. As she walked, Sisinni struggled to recite every other letter of the alphabet ("B, D, F, H"), while the sensor on her forehead measured activity in her prefrontal cortex, and the carpet simultaneously registered the location, path, and velocity of every step.

"You're doing great!" said Roee Holtzer, a neuropsychologist at Albert Einstein College of Medicine who has been conducting studies of brain function and mobility in the elderly.

If this sounds like a scientific variation on the old joke about being able to walk and chew gum at the same time, go ahead and laugh. In a series of studies over the past several years Holtzer and neurologist Joe Verghese have shown that the amount of thinking people are able do in the executive, prefrontal part of the brain while they walk and talk predicts the risk of dementia, loss of mobility, and falls.

These experiments complement research at Einstein led by Nir Barzilai, an Israeli doctor with a mop of gray hair atop a youthful face who

MARION STEHURA

103

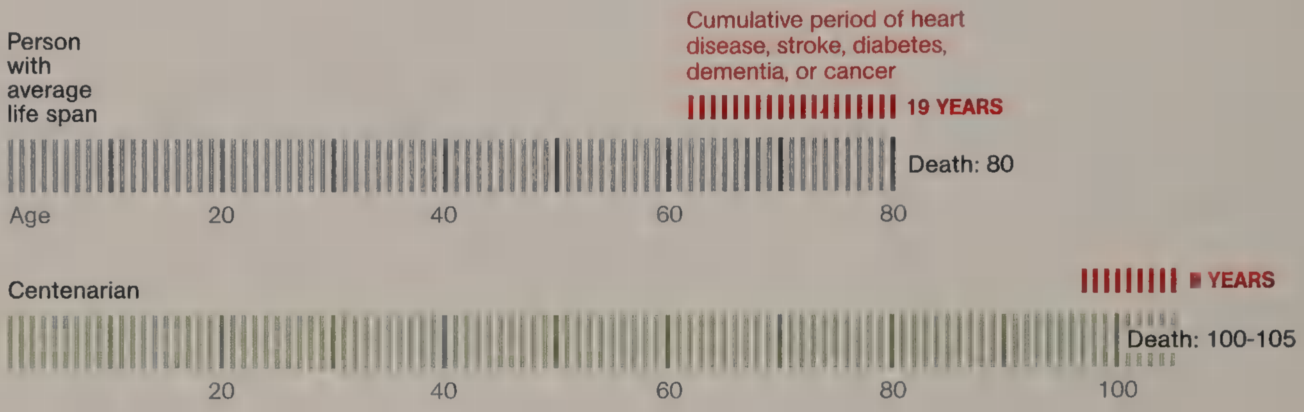
Growing up in Lorain, Ohio, Stehura wanted to "do the things the boys do," like play ball and "be rough." Today, in Hemet, California, she gets a kick out of whistling loud and long in big-box stores when she shops with son John; it's the way she used to call her sons home when they were young. Riding in an electric cart provided by the store, she brags, "My whistle could blow this place to pieces."

"Don't let anyone bull crap you.
Fight, fight for your rights."

FROZEN F

Getting to 100 candles

Centenarians reach that milestone because they're healthier, by virtue of genetics, common sense, or luck. In people with an average life span, diseases of old age strike earlier and last longer.



in 1998 began a study of three New York centenarians. The Einstein project has since grown to include more than 500 centenarians in and around New York City—all from central Europe and all Ashkenazi Jews, a historically isolated and culturally insular population. In this homogeneous group, research has again revealed a set of genes related to longevity, some of which have also turned up in Italy.

As they gathered more and more data, the Einstein researchers noticed that the Ashkenazi centenarians had exceptionally high levels of HDL, often called the good form of cholesterol, and that the children of these centenarians had even higher levels. This sent them off to analyze the DNA of about a hundred genes known to be involved in cholesterol metabolism. What they found was a variant, a distinct genetic subtype, of a gene known as *CETP* (cholesteryl ester transfer protein) that was more common in centenarians than in others.

When they investigated the centenarian version of the *CETP* gene, they confirmed earlier research showing that this particular variant protects against cardiovascular disease, and they have gone on to show that many people with this genetic subtype—not just centenarians but other Ashkenazi Jews and even non-Jewish residents of the Bronx—perform better on cognitive tasks like the "walking while talking" experiments. Two major pharmaceutical companies are now testing drugs that inhibit the amount of *CETP*, as the centenarian gene variant does.

Barzilai and his colleagues have also focused on the mitochondria of centenarians. Mitochondria are the cell's power plants, with their own DNA, their own genes, their own genetic variants—all with key metabolic responsibilities. Barzilai and his team have identified several mitochondrial proteins, which they dubbed mitochines, associated with people who live into their 90s and 100s. One of these molecules, humanin, looks especially interesting, at least in animal experiments. Barzilai says that giving a single shot of humanin to a diabetic rat normalizes its glucose levels and essentially erases diabetic symptoms in a few hours. It also prevents arteriosclerosis and Alzheimer's in mice prone to these diseases and somehow limits coronary damage when researchers induce heart attacks in the experimental animals.

Einstein's large and ambitious longevity program is part of a sea change sweeping human genetics research, where the prevailing emphasis for the past 20 years has been on the search for so-called disease genes. "Everybody is looking

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■ **Society Grant** Biologist Valter Longo's research on Laron syndrome was funded in part by your National Geographic Society membership.

NGM ART. SOURCE: THOMAS PERLS, NEW ENGLAND CENTENARIAN STUDY, BOSTON UNIVERSITY for genes for diabetes and obesity and things like that," says Barzilai. "I think one reason we are not finding them is because we also have protective sets of genes." Many researchers are now focused largely on the search for those protective genes, which seem to override genes associated with disease or aging.

One of the most intriguing genes is called *FOXO3*. In yet another study of an isolated, homogeneous population, University of Hawaii researchers have found variants of the gene in long-lived Japanese-American men on the island of Oahu. This gene is in the same insulin–IGF-1 pathway that has popped up both in studies of yeast and worms and in the Laron population in southern Ecuador.

Protective genes are also the target of a study at the Scripps Translational Science Institute in La Jolla, California, where physician Eric Topol and colleagues are riffling through the DNA of about a thousand people they call the wellderly. These are people over the age of 80 who have no chronic diseases, such as high blood pressure, coronary artery disease, or diabetes, and have never taken prescription drugs for them. "There must be modifying genes that explain why these individuals are protected from the deleterious genes that affect the aging process," Topol says. "The hunt is on."

The race to find the keys to longevity has even led scientists to a place that looks increasingly important in setting every individual's rate of aging: the womb. Researchers at Einstein now suspect that our pattern of aging may be set very early, perhaps before we're born.

To study this hypothesis, Francine Einstein and John Greally have been examining subtle chemical markings on the DNA of stem cells recovered from the umbilical cord blood of babies born in the Bronx and comparing differences in infants who were, for their gestational age, small, normal, or large. They have found that the pattern of DNA markings in both small and large infants is significantly different compared with that of normal-size babies. These results form part of a hot new field of biology called epigenetics, which studies how environmental influences can etch chemical modifications in DNA and thus introduce lifelong changes in the activity of genes. As Barzilai explains it, "There might be influences in the uterus that affect genetic mechanisms that somehow set your rate of aging." The fetus, in other words, may be father of the old man.

IF NOTHING ELSE, the plethora of new studies indicates that longevity researchers are pushing the scientific conversation to a new level. In October 2011 the Archon Genomics X Prize launched a race among research teams to sequence the DNA of a hundred centenarians (dubbing the contest "100 over 100").

But genes alone are unlikely to explain all the secrets of longevity, and experts see a cautionary tale in recent results concerning caloric restriction. Experiments on 41 different genetic models of mice, for example, have shown that restricting food intake produces wildly contradictory outcomes. About half the mouse species lived longer, but just as many lived less time on a restricted diet than they would have on a normal diet. And last August a long-running National Institute on Aging experiment on primates concluded that monkeys kept on a restricted-calorie diet for 25 years showed no longevity advantage. Passarino made the point while driving back to his laboratory after visiting the centenarians in Molochio. "It's not that there are good genes and bad genes," he said. "It's certain genes at certain times. And in the end, genes probably account for only 25 percent of longevity. It's the environment too, but that doesn't explain all of it either. And don't forget chance."

Which brought to mind Salvatore Caruso of Molochio, now 107 years old and still going strong. Because he broke his leg 88 years ago, he was unfit to serve in the Italian Army when his entire unit was recalled during World War II. "They were all sent to the Russian front," he said, "and not a single one of them came back." It's another reminder that although molecules and mechanisms yet unfathomed may someday lead to drugs that help us reach a ripe and healthy old age, a little luck doesn't hurt either. ☐

What's the secret to long life? Thriving seniors share their wisdom in a video on our digital editions.

SALVATORE CARUSO

106

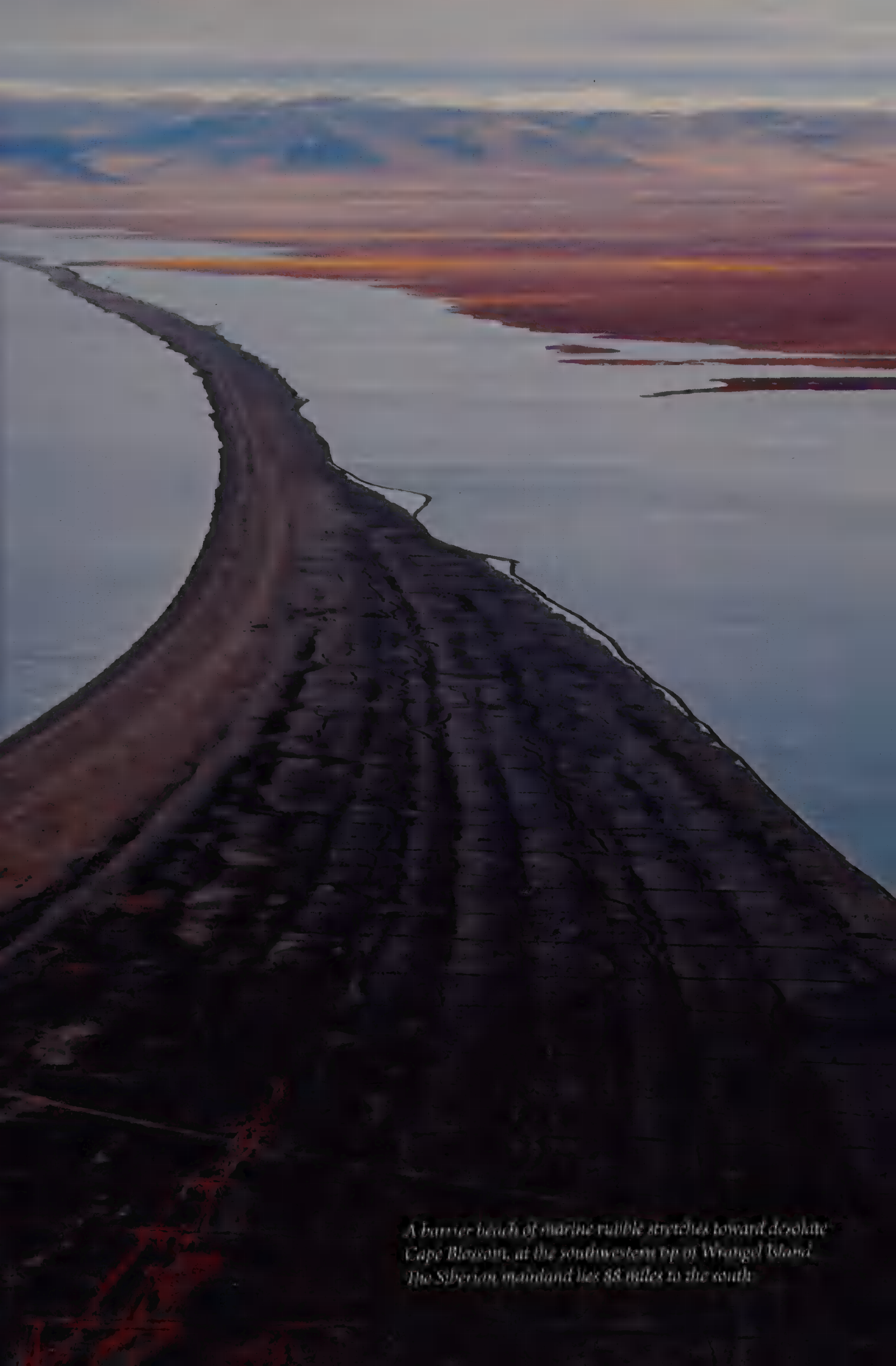
Caruso walks on his own, does not need glasses, recites Dante aloud, and enjoys singing with his grandsons. Some of his earliest memories are of the olive groves that fill the family land in Molochio, Italy. Although techniques have changed—nets now catch the olives he used to gather by hand—he has participated in the harvest and helped produce olive oil throughout his life.

"As a baby, I was laid on a blanket here during the olive harvest."

RUSSIAN REFUGE

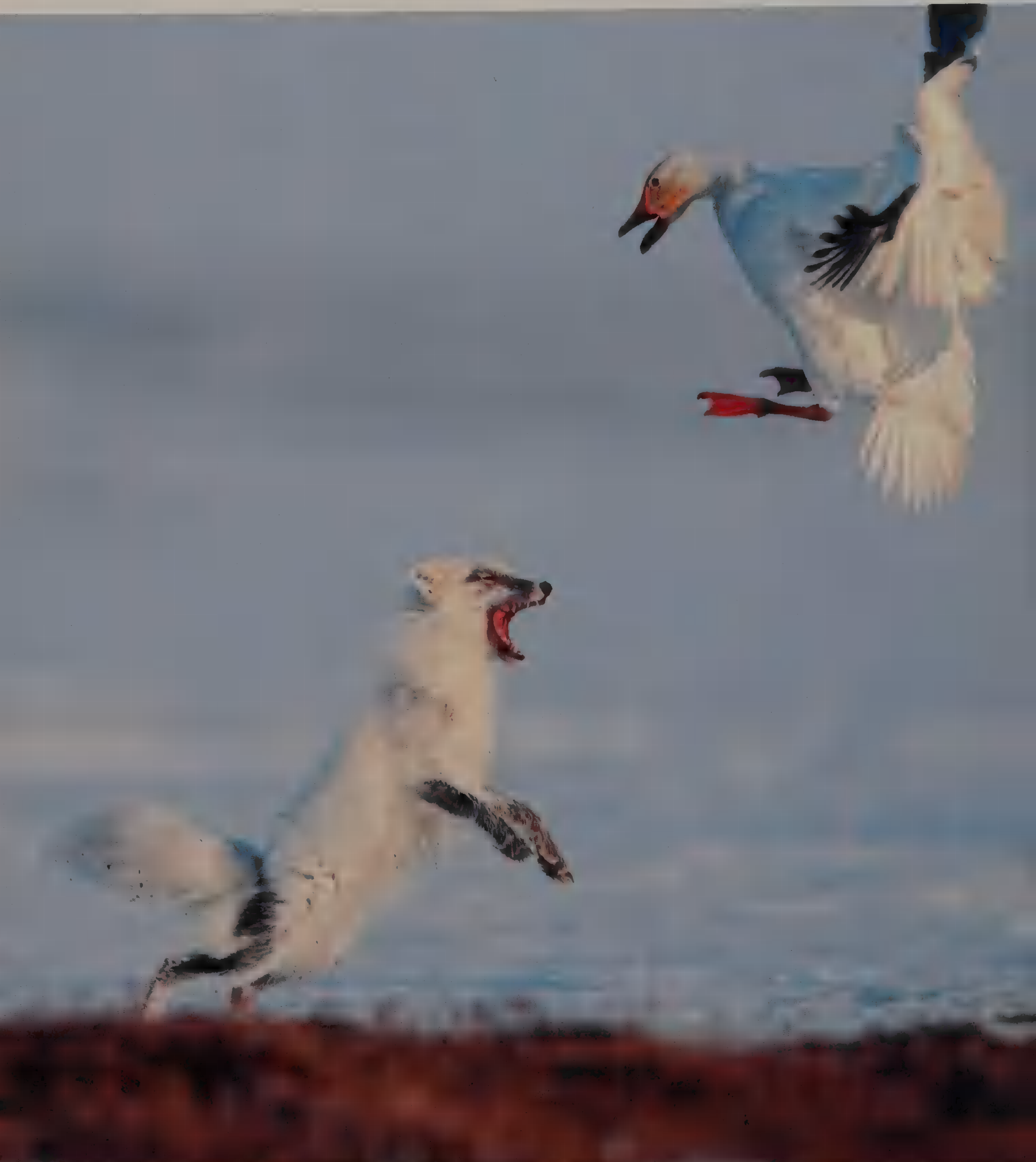
WRANGEL ISLAND
IS A HAVEN FOR WILDLIFE,
FROZEN IN SPACE
AND TIME

The Artful Dodgers of Wrangel Island,
arctic foxes steal as many as 40 snow goose eggs a day
and cache them for their pups.



A barrier beach of marine rubble stretches toward desolate Cape Blossom, at the southwestern tip of Wrangel Island. The Siberian mainland lies 88 miles to the south.

Muskoxen—more akin to goats and sheep than to oxen—were introduced to Wrangel Island in 1975 and now number about 800. Increasingly, they cluster in tight groups to fend off a newly returned predator: wolves.



A feisty fox drives a snow goose from her nest, a gambit before an act of egg thievery.
A colony of geese migrates to the island in May after wintering in North America.

BY HAMPTON SIDES

PHOTOGRAPHS BY SERGEY GORSHKOV

THE ZODIAC RAFT motors through the freezing drizzle, skirting large ice cakes, taking on wave after invigorating wave of Chukchi Sea as we grope our way toward a shore obscured by fog. Although our Russian guide insists that a large island lies just ahead, I'm doubtful. But then the mists dissipate, and suddenly it looms with a starkness enhanced by the refractions of the Arctic atmosphere: a formidable piece of real estate, 91 miles long, its golden mountains speckled with the bright blooms of tundra flowers.

John Muir, the first visitor to describe Wrangel Island to the world, waxed rhapsodic when he saw this vista in 1881. "This grand wilderness in its untouched freshness," Muir called it, this "severely solitary" land in the "topmost, frost-killed end of creation."

Today Wrangel Island is one of the world's least frequented, most restricted nature reserves—a place that requires several government permits to visit and can be reached only by helicopter during winter or by icebreaker during summer. Waiting for us beside the landing site at Rodgers Cove is Anatoliy Rodionov, a strapping Russian preserve ranger in dun-colored fatigues who carries a flare gun and a can of Counter Assault pepper spray. Rodionov lives year-round here, more or less marooned with a few colleagues and a population of hungry polar bears.

"*Privet* and welcome to Ostrov Vrangelya!" he says, with the exaggerated cheer of a young man starved for sun and human company. "For nine months only three colors—white, black, gray. I doesn't like the winter here!"

Rodionov leads us across a gravel beach strewn with the bones of whales and walruses to Ushakovskoye, a tiny ghost town from the Soviet era. Rusty barrels are piled everywhere. Weather-scabbed cabins, some of which have been cannibalized for firewood, are built upon a spongy turf of lichen and moss. Disintegrating radar disks lean toward the sea, and a radio antenna's guy wires sing in the high wind. The windows of a Russian bathhouse are caged and spiked with five-inch nails to keep out the bears.

Three hundred yards away an alert young male sniffs with interest. Rodionov eyes him knowingly. "That rascal," he says with a laugh. "He pay us a visit last night."

WRANGEL ISLAND was declared a *zapovednik*—a federally managed nature sanctuary—in 1976, and it remains one of Russia's coldest, remotest pieces of protected wilderness. The 2,900-square-mile island lying astride the 180th meridian just might be the Galápagos of the far north: Despite the severity of its climate, and in many ways because of it, Wrangel boasts an astonishing abundance of life. The island is the world's largest denning ground for polar bears—as many as 400 mothers have been known to land here in winter to raise their young. With climate change making the ice pack much less

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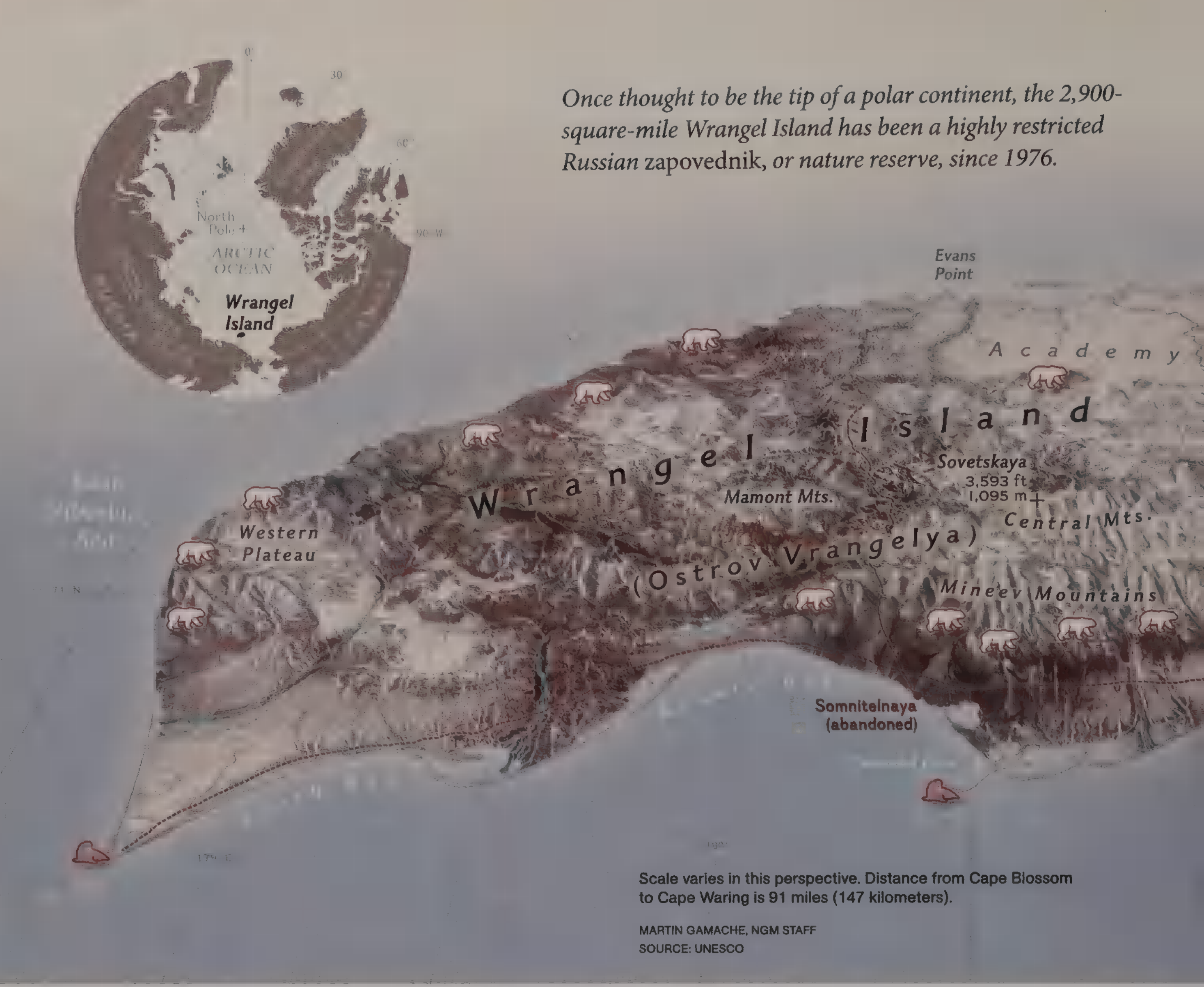
Hampton Sides is writing a book about the Arctic voyage of the U.S.S. Jeannette. *This is Sergey Gorshkov's first assignment for the magazine.*

A mother polar bear and her two cubs search for prey. Wrangel Island has been called the world's polar bear maternity ward. Some years hundreds of mother bears overwinter here with their young.



Once thought to be the tip of a polar continent, the 2,900-square-mile Wrangel Island has been a highly restricted Russian zapovednik, *or nature reserve, since 1976.*

Scale varies in this perspective. Distance from Cape Blossom to Cape Waring is 91 miles (147 kilometers).

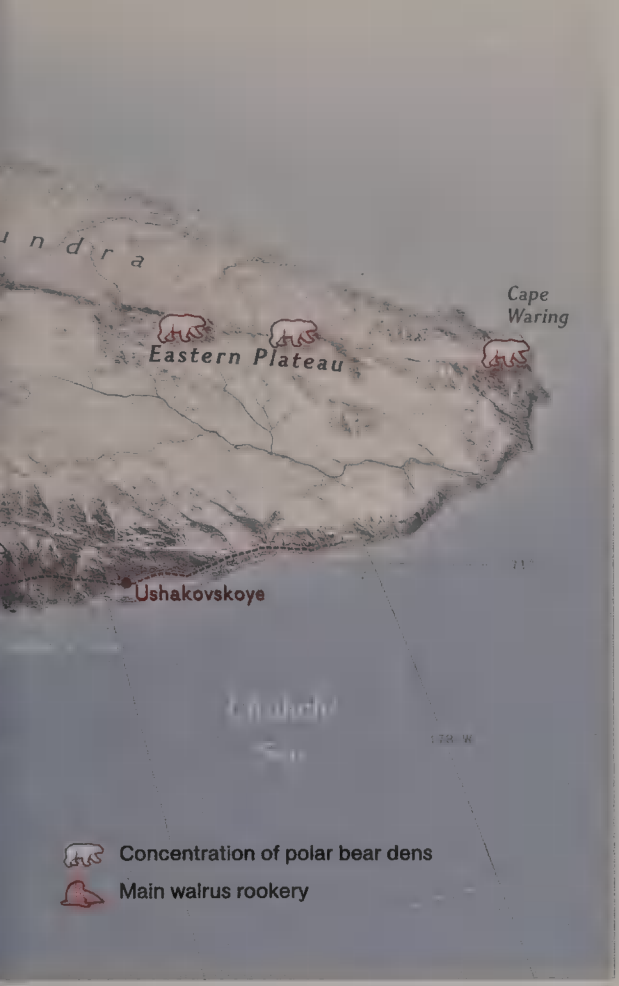
MARTIN GAMACHE, NGM STAFF
SOURCE: UNESCO

reliable, polar bears have often sought summertime refuge on the island in recent years as well. Wrangel also supports the largest population of Pacific walruses, and the only snow goose nesting colony in Asia. It is home to snowy owls, muskoxen, arctic foxes, and reindeer as well as massive populations of lemmings and seabirds. And yet, in merciful contrast to the boggy Siberian mainland, there are no mosquitoes.

Since ancient times Wrangel Island has been felicitously perched on what might be called the ice cusp. Because the island was never completely glaciated during recent ice ages and never completely inundated by seawater during periods of ice retreat, the soils and plants in its interior valleys offer a glimpse of undisturbed Pleistocene tundra unique on the planet. "When you go to Wrangel," says Mikhail Stishov, a Moscow-based WWF scientist who lived 18 years on the island, "you're going back hundreds of thousands of years. It's a place of ancient biodiversity, but it's also very fragile."

Paleontologists believe Wrangel is also the last place where woolly mammoths lived. A dwarf subspecies thrived here as late as 1700 B.C., more than 6,000 years after mammoth populations elsewhere became extinct. Their curved tusks can be found everywhere on the island, lying on the gravel beaches, in streambeds, even leaning against ranger cabins—trophies from another epoch. "When the pyramids were being built in Egypt, elephants walked around on Wrangel," says Alexander Gruzdev, the reserve's director. "Its proximity to, but isolation from, the continental patterns of Asia and North America created a unique natural structure. There's no place quite like it in the world."

THOUGH ARCTIC ANIMALS have long flourished on Wrangel, people most emphatically have not. Lying 88 miles off the coast of northeastern Siberia, Wrangel was for centuries little more than



a rumor, a mirage, a fog-gauzed dream. Perhaps it was an island, perhaps a continent, perhaps a magical gateway to the Pole. Throughout much of the 19th century "Wrangell Land" functioned as a kind of ultima Thule, a hypothetical realm just beyond the veil of the known world. Before its existence was proved, Wrangel Island went by a succession of tentative names: Tikegen Land, Plover Island, Kellett Land. Wrangel loomed in cartographers' imaginations—some even surmised that it was an extension of Greenland that stretched clear across the Pole.

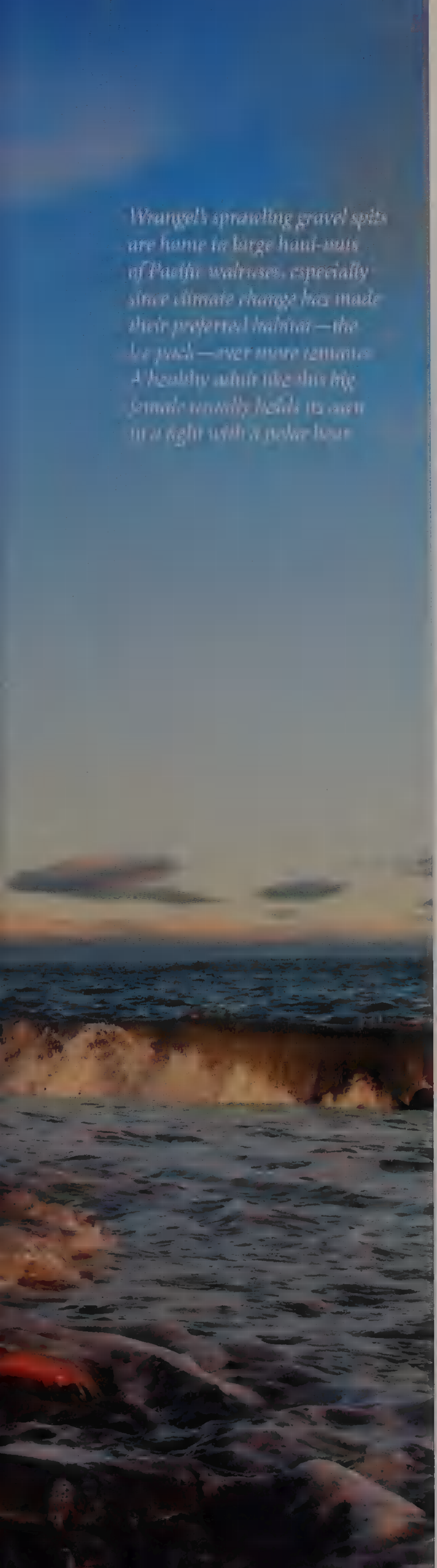
Throughout the 1800s and early 1900s almost every exploring expedition that blundered anywhere near Wrangel ended up with the adjective "doomed" in front of it. In the early 1820s Chukchi hunters on the northeast Siberian coast told Russian explorer Ferdinand von Wrangel about a land to the north that could sometimes be seen when atmospheric conditions were just right. Wrangel sailed for the mythic land but was thwarted by ice and failed to snatch even a glimpse of it. Nearly 30 years afterward, the captain of an English vessel searching for Sir John Franklin's expedition thought he spotted a large Arctic island shimmering in the distance. Later, various whaling captains insisted they'd seen it, although their claims were disputed, since the Arctic is notorious for fata morganas and other fantastical illusions.

An American Arctic expedition launched in 1879 drifted close to Wrangel—close enough for its commander, George Washington De Long, to determine that it was not a polar continent after all. De Long was never able to land on Wrangel, however; his ship, the U.S.S. *Jeannette,* was beset in the polar ice pack for nearly two years, until it sank some 800 miles to the northwest.

It wasn't until August 1881 that a group of Americans aboard the steamer *Thomas L. Corwin,* scouring the Arctic in search of the lost *Jeannette,* set foot on Wrangel and proved its hard-soil existence once and for all. The search party, which included the young Muir, hoisted an American flag and declared Wrangel a new U.S. possession in the name of their President. (Unbeknownst to the explorers, President James Garfield lay slowly dying from an assassin's bullet.)

The *Corwin* party called the island New Columbia, but the name never stuck. That same year Muir published the world's first description of Wrangel in a San Francisco newspaper series, later collected in a piquant travelogue called *The Cruise of the* Corwin. Although he considered Wrangel a "notable addition…to the national domain," Muir thought the geography of the new land would not be known "until some considerable change has taken place in the polar climate."

The island dwelled in near solitude for over 30 years. Then came another succession of doomed expeditions, beginning with the Canadian Arctic Expedition of 1913, whose survivors were forced to leave their crushed brigantine *Karluk* and trudge 80 miles over the ice pack to take refuge on Wrangel. By the time they were rescued eight months later, 11 of the 25 men had perished on or near Wrangel. A Canadian-led attempt in 1921 to settle Wrangel Island and



Wrangel's sprawling gravel spits are home to large haul-outs of Pacific walruses, especially since climate change has made their preferred habitat—the ice pack—ever more remote. A healthy adult like this big female usually holds its own in a fight with a polar bear.

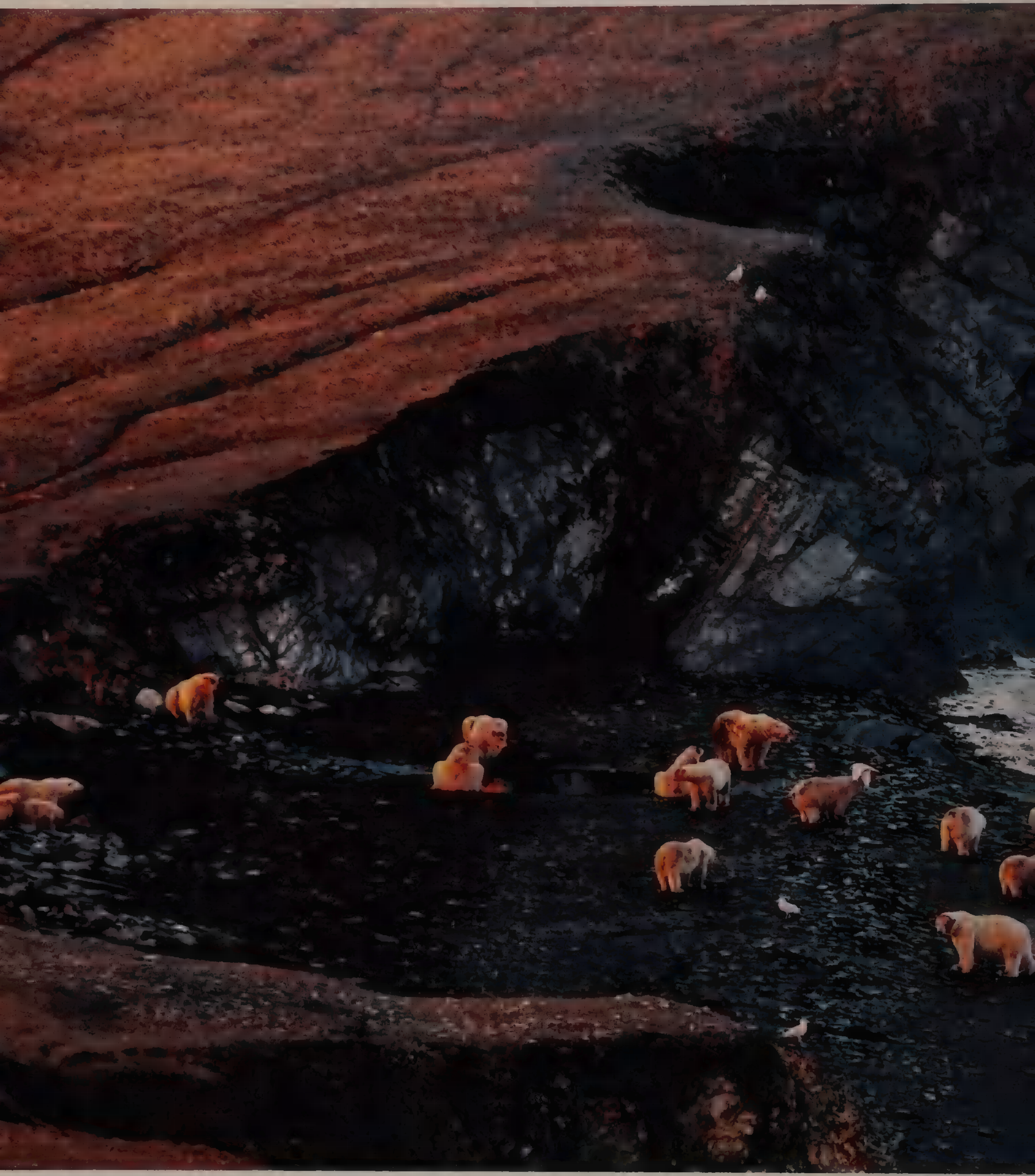
claim it for the British motherland resulted in four more deaths.

In 1926 the Soviets, attempting to extend their sovereignty over Wrangel, forcibly relocated Chukchi there from Siberia. A tiny colony persisted until the 1970s, when, with the creation of the sanctuary, descendants of the original settlers started being repatriated to the mainland.

Because the *Corwin* party was the first to plant a flag on Wrangel, certain jingoistic groups in the United States have insisted the island is rightfully American soil. One Tea Party blogger last year ranted that President Barack Obama was giving away Wrangel to the "Putin regime" as part of an "apparent war against U.S. energy independence." The U.S. State Department, however, has long maintained that the United States asserts no territorial claim to the island—and never has. The region around Wrangel is not known to have substantial oil reserves, and even if it did, its nearly year-round ice would likely make extraction prohibitively difficult and expensive.

Thus blessed with a lack of exploitable resources, Wrangel has been left alone. Thanks to climate change and the Cold War's end, the island has become slightly more accessible in recent years, and the Russian Ministry of Natural Resources and Environment has unveiled plans to develop ecotourism here, but that seems a long way off. For the foreseeable future Wrangel will remain a natural laboratory for Arctic animals and the humans who study them. Scientists who come here say there is something peculiarly haunting and powerful about this raw Pleistocene landscape secreted near the roof of the world. "You feel as though you've come to the end of the Earth," says University of Michigan mammoth paleontologist Daniel Fisher.

"It's such a pristine environment," says Irina Menyushina, who has spent 32 seasons on Wrangel Island conducting snowy owl and arctic fox studies. "You feel yourself so close to the primeval processes of the universe—birth, death, survival, the ebb and surge of populations. Every year when I'm back on Wrangel, I am reinfected by the Arctic." ☐



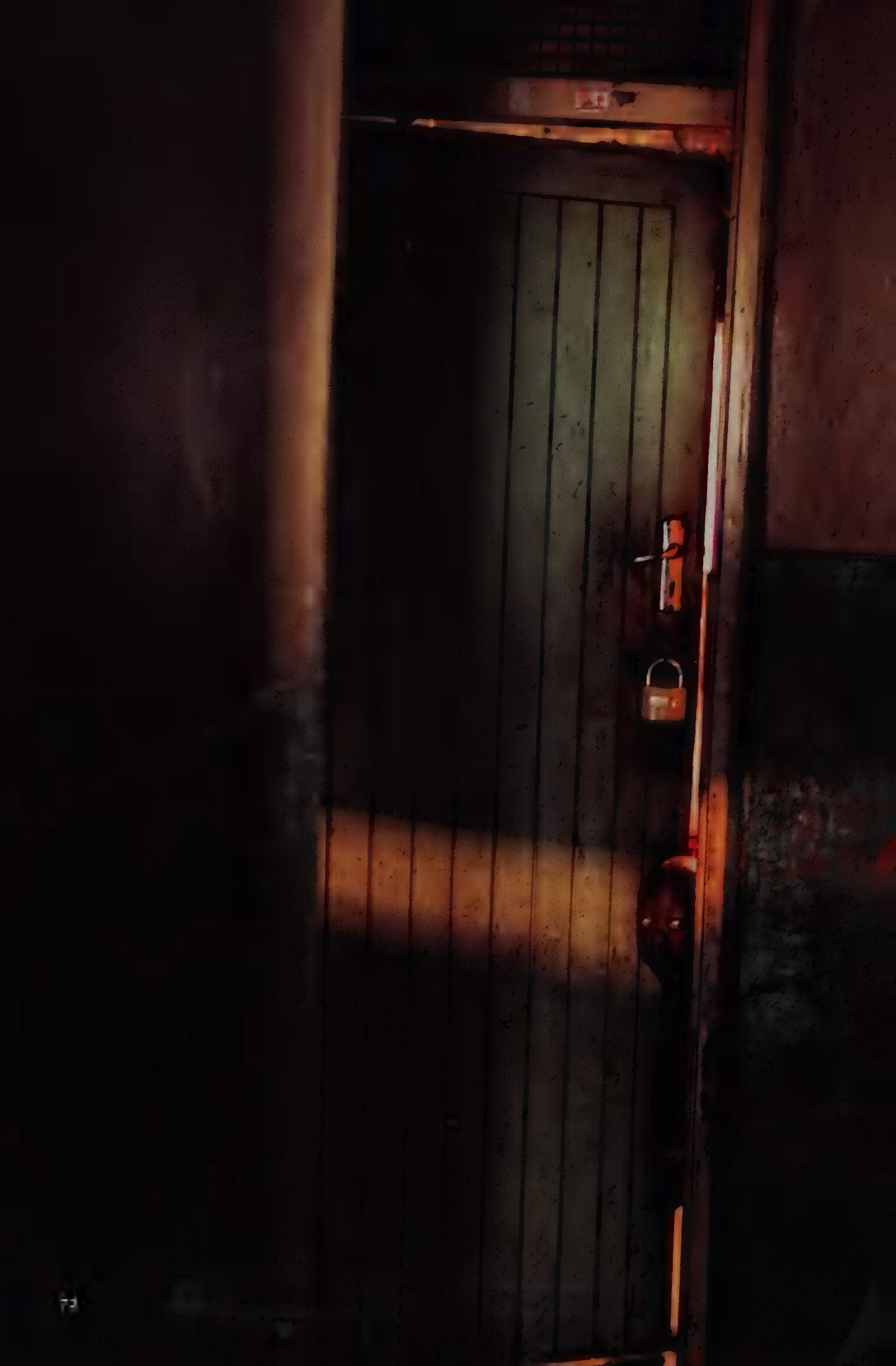
Most of the year polar bears rarely congregate. But in summer on the rocky shores of this seabird rookery they share the bounty with surprising ease.

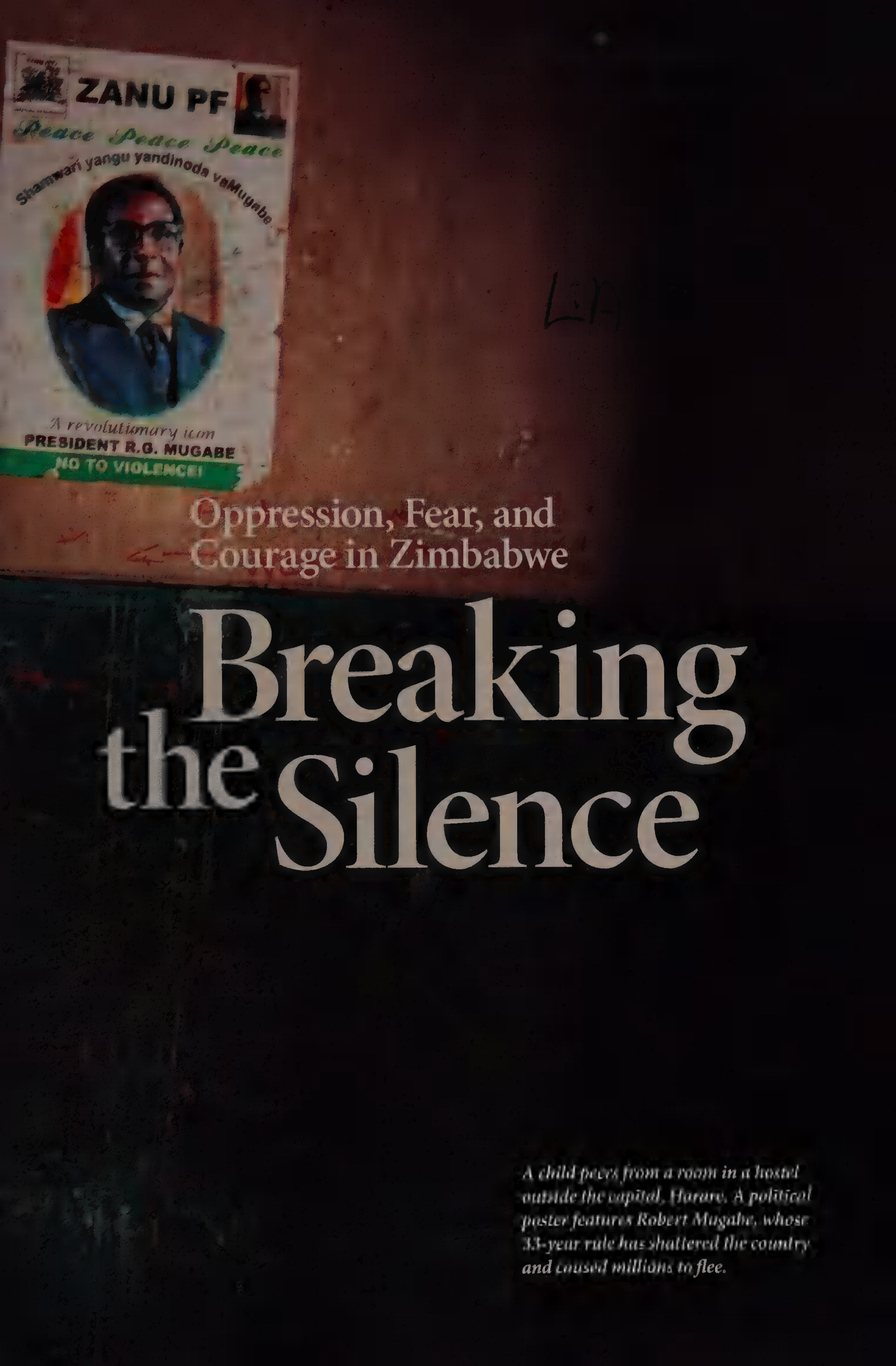
An arctic fox pup, just beginning to show its white winter coat, plays with a lemming carcass. Wrangel's foxes subsist largely on these snow-burrowing rodents, whose numbers fluctuate wildly from year to year.

In August fledgling snowy owls begin to fly—sometimes with laughable results. This young owl, having nose-dived into a river, uses its wings like oars to propel itself across the water.

Wrangel's wild beauty comes to life in a video on our digital editions.

Two bull muskoxen size each other up. In September, with mating season under way, bulls engage in frequent head-butting confrontations to establish dominance.



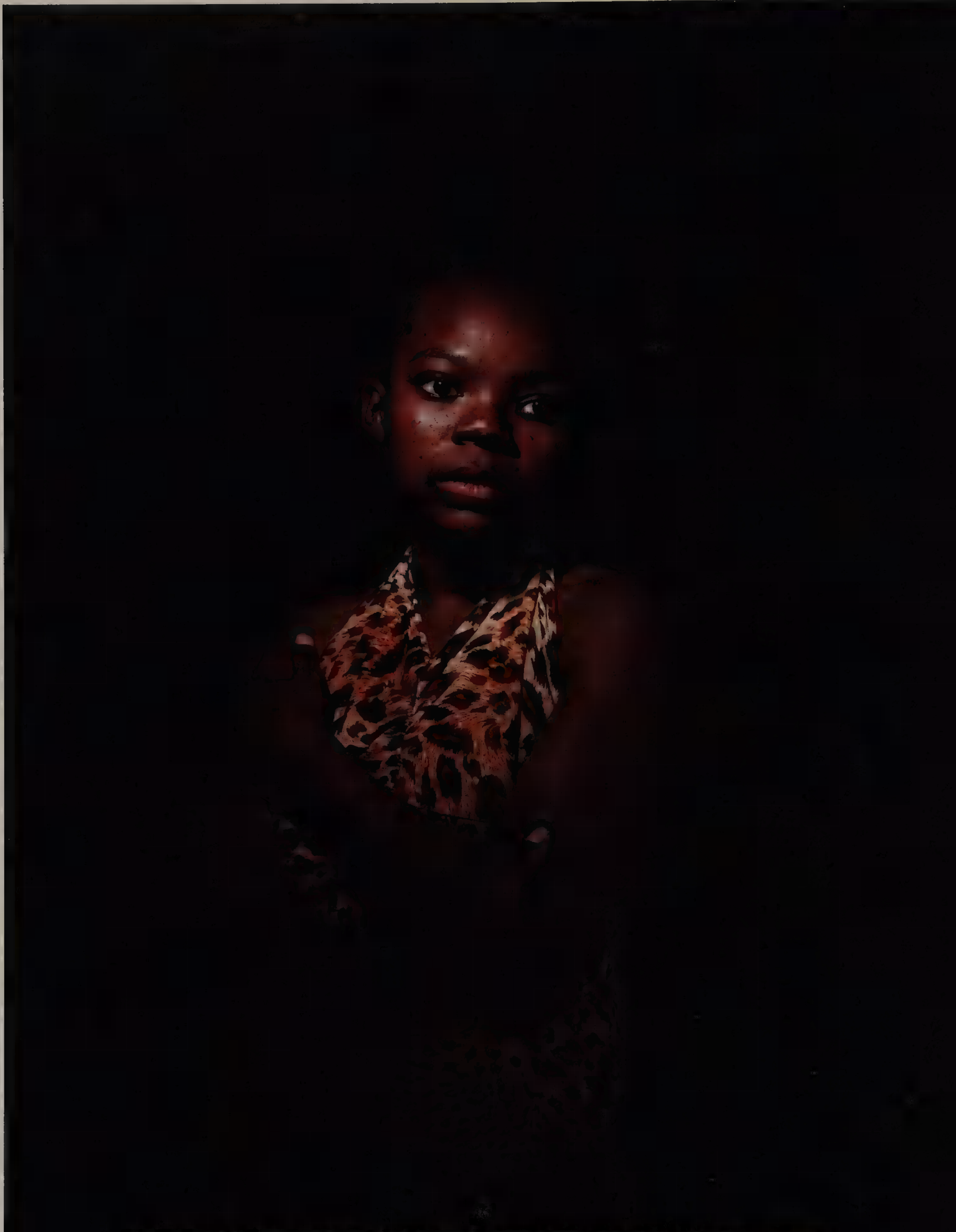

ZANU PF
Peace Peace Peace
Shamwari yangu yandinoda vaMugabe
A revolutionary icon
PRESIDENT R.G. MUGABE
NO TO VIOLENCE!

Oppression, Fear, and Courage in Zimbabwe

Breaking the Silence

A child peers from a room in a hostel outside the capital, Harare. A political poster features Robert Mugabe, whose 33-year rule has shattered the country and caused millions to flee.

In the derelict yard of a meat processing plant in Bulawayo, a globe locates Zimbabwe's former beef export markets. A decade ago haphazard land reform crippled the country's ranching industry.



EVELYN, 14, REFUGEE IN A WOMEN'S SHELTER, MUSINA, SOUTH AFRICA

"I want to be a lawyer. I need to help people who are sick,
and people who don't have anywhere to stay, and then they steal or they do something,
so I have to defend them so that they cannot be arrested."

By Alexandra Fuller
Photographs by Robin Hammond

There are at least two things to know about Zimbabweans. The first is that they have an immoderate attachment to their land, and no wonder. Anyone who has seen the spring-red blush of *musasa* woodland at the beginning of the rains, or felt the crackle-hot wind of a lowveld summer afternoon, or absorbed the scents of sweet potato and marigold as dusk settles over the bush will know that theirs is a soul-snagging land. Of course such an attachment to land comes at a price. For it, and over it, there will be wars and revolutions, and the inevitable loss of land by the vanquished or the politically unlucky will be so unendurable that the unmoored people will end up true ghosts, souls in search of soil.

The second thing to know about Zimbabweans is that they are a small but persistently noisy nation of storytellers and musicmakers. The Bhundu Boys were pop diva Madonna's supporting act at Wembley Stadium in London in 1987. Thomas Mapfumo, the Lion of Zimbabwe, created a genre of protest music—*chimurenga* (uprising). Africa's most prestigious literary award, the Caine Prize, has twice gone to Zimbabweans in its 13-year history (Brian Chikwava in 2004, NoViolet Bulawayo in 2011). Charles Mungoshi won two Pen International awards in 1976, and Dambudzo Marechera won the Guardian Fiction Prize in 1979. Doris Lessing, who spent her formative years in the country, won the Nobel Prize in literature.

I AM NOT NOW ZIMBABWEAN, but for several years in the 1970s my British-born parents owned a farm on the eastern edge of what was then the rogue state of Rhodesia. They fought—my father as a conscripted soldier, my mother as a police volunteer—to keep the country white-run and avowedly out of the hands of communists. By any calculation, it was a questionable cause: Ian Smith, Rhodesia's prime minister, campaigned in 1965 on a slogan of "A whiter, brighter Rhodesia," and for the next decade and a half a decreasing minority of whites (just over 200,000 in the early '60s to about 150,000 in 1980) tried to hold on to power in a country populated by a black majority that grew from about 3.5 million to more than 7 million during that period.

By late 1979 liberation forces were coming into Rhodesia from camps in neighboring Mozambique and Zambia faster than government troops could kill them. A peace was negotiated. The following February general elections were held and won by the Zimbabwe African National Union—Patriotic Front (ZANU-PF). Its leader became Zimbabwe's first prime minister. Robert

Hear the personal stories behind some of these portraits on our digital editions.

Working along fault lines well established by the minority government before him—ethnic, racial, and political—Mugabe went about further dividing his nation and securing absolute power for himself.

Gabriel Mugabe exuded an air of conciliatory magnanimity. My mother wasn't buying it. My parents moved north to Malawi.

Working along fault lines well established by the white minority government before him—which is to say, ethnic, racial, and political—Mugabe went about further dividing his nation and securing absolute power for himself.

There are two main ethnic groups in Zimbabwe: the majority Shona and the minority Ndebele. Mugabe is Shona. In 1983 Mugabe deployed his North Korean-trained Five Brigade into the west of the country to preempt any Ndebele political opposition. Over the following five years, an estimated 20,000 Ndebele were massacred. "He understood and manipulated our weaknesses very well," Wilfred Mhanda, a former ZANU-PF liberation commander who fought along with Mugabe, told me. "There is nothing more deadly than someone so profoundly insecure mimicking the aggression of his oppressors and becoming an oppressor in turn."

Mugabe tolerated corruption in his cabinet, as long as it came with loyalty to him. The country's economy was collapsing, and by the mid-1990s there were fuel shortages, civil servants were striking, and liberation war veterans began to demand the compensation they had been promised at independence. Then, in 1998, Mugabe sent troops into the Democratic Republic of the Congo to prop up the teetering regime of Laurent Kabila, at an eventual cost equivalent to a million U.S. dollars a day. Zimbabwe's economic fate was sealed.

THE MOVEMENT FOR DEMOCRATIC CHANGE (MDC) was launched in 1999, headed by a former labor union leader, Morgan Tsvangirai. Mugabe countered the new political outspokenness this came with and the increasing dissatisfaction among his own supporters by allowing them to appropriate white-owned commercial farms without compensation. In 2000, with Mugabe's explicit blessing, unemployed ZANU-PF supporters led by war veterans armed with axes and machetes invaded the farms, shouting, "*Hondo!* War!" Domestic food supplies plummeted. In 2005, after the MDC won several parliamentary seats, Mugabe retaliated with Operation Murambatsvina (Operation Clear the Filth). Across the country market stalls and homes belonging to the urban poor, who constituted much of ZANU-PF's opposition, were razed. An estimated 700,000 people lost their homes or livelihoods, and more than 2 million were driven further into poverty.

Then, in a first round of elections held in 2008, Mugabe's ZANU-PF finally lost to Tsvangirai's MDC. Calling for a runoff election, supporters and officials of ZANU-PF went on a vicious state-sponsored rampage. Hundreds of MDC supporters were killed and thousands injured, hundreds of women and girls were raped, and tens of thousands of people became internal refugees. "If you wanted to commit suicide in 2008, you just wore an MDC T-shirt," I was told. By November of that year, Steve Hanke, an economics professor at Johns Hopkins University in Baltimore, had calculated Zimbabwe's monthly inflation rate at 79.6 billion percent, second only to Hungary's in 1946.

To avoid worse bloodletting and even more unimaginable economic collapse, Tsvangirai

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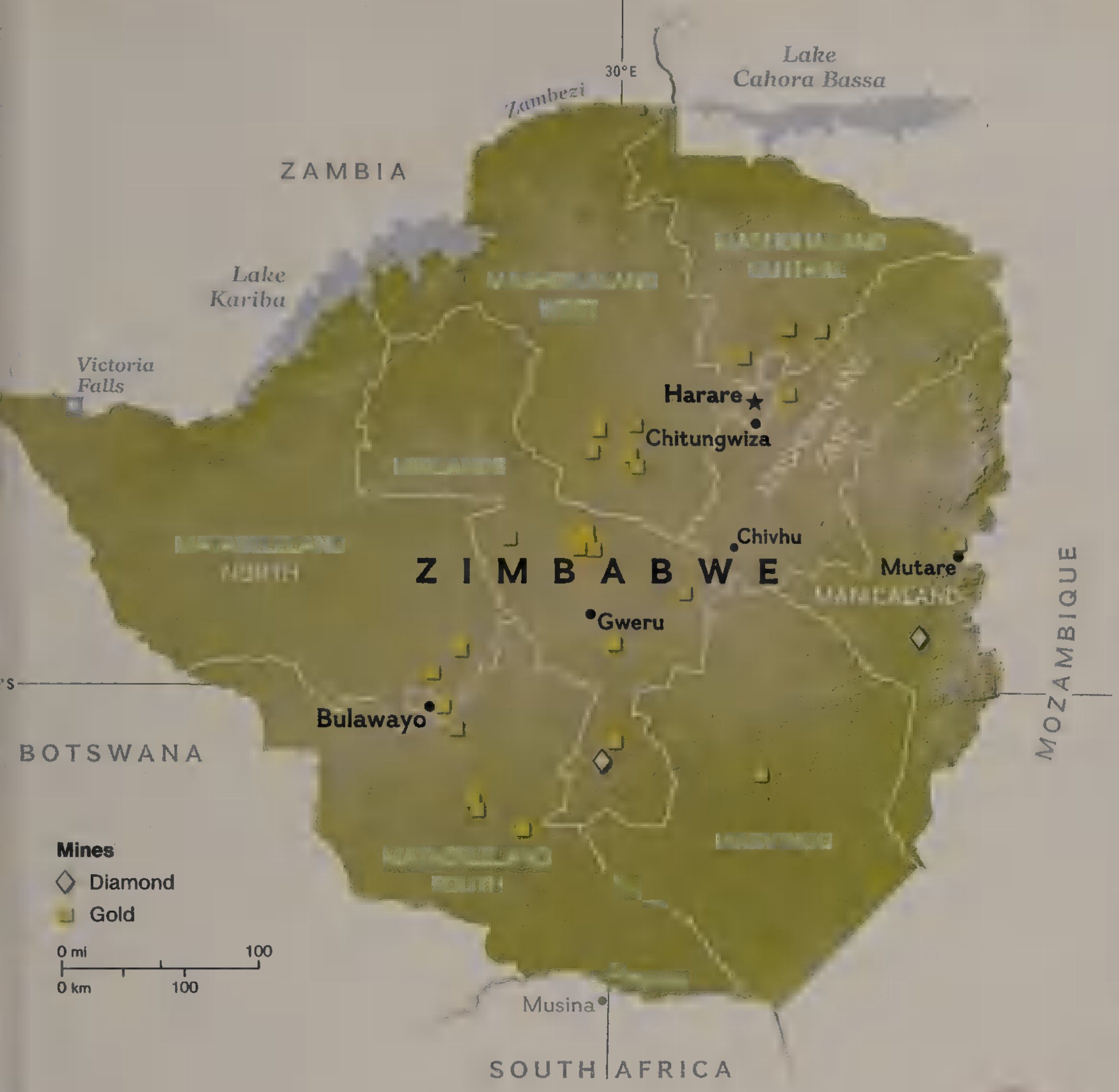
Alexandra Fuller's family memoir, Cocktail Hour Under the Tree of Forgetfulness, *appeared in 2011. That year Robin Hammond received the Carmignac Gestion Photojournalism Award, which enabled him to spend five months in Zimbabwe last year.*


30°E
Zambezi
Lake
Cahora Bassa
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Lake
Kariba
Victoria
Falls
Harare
Chitungwiza
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ZIMBABWE
Mutare
MANICALAND
Gweru
NORTH
Bulawayo
BOTSWANA
MOZAMBIQUE
Musina
SOUTH AFRICA
Mines
◇ Diamond
▪ Gold
0 mi 100
0 km 100

A Corrupt and Bloody Reign

Robert Mugabe won election as Zimbabwe's first prime minister in 1980. He's held on to power through violence and intimidation: Attacks by government-backed forces on civilians who could oppose him have peaked in election years (maps, right). The country's natural resources—including gold and remarkable diamond deposits—have helped finance Mugabe's rule, enriching him and his inner circle.

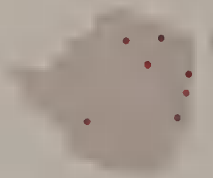
DEMOCRATIC
REPUBLIC OF THE
CONGO
TANZANIA
INDIAN
OCEAN
AFRICA
ANGOLA
MALAWI
ZAMBIA
Harare
ZIMBABWE
MOZAMBIQUE
MADAGASCAR
NAMIBIA
BOTSWANA
SOUTH
AFRICA
ATLANTIC
OCEAN
0 mi 500
0 km 500

1965
The white government of the country of Rhodesia unilaterally declares independence from Great Britain rather than accept a plan for black-majority rule.

1979-1980
Blacks gain power in a war of liberation and rename the country Zimbabwe. Robert Mugabe is elected prime minister.

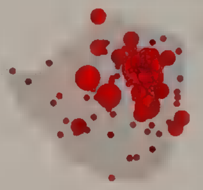
1982-87
Government forces kill 20,000 ethnic Ndebele in the west thought to oppose Mugabe.

1998
Mugabe sends troops into a war in the Democratic Republic of the Congo. The cost drains an already collapsing economy.

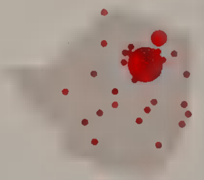


1999
A new party opposing Mugabe is formed: the Movement for Democratic Change (MDC).

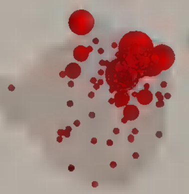
2000-2001
Government-sanctioned seizures of white-owned farms intensify. National food supplies crash.



2002
Mugabe defeats MDC and wins reelection. Violence spikes; freedom of speech and press curtailed.



2005
In the government's Operation Clear the Filth, 700,000 people in areas of MDC support lose their homes and businesses.



2008
Election-year violence spikes again. MDC wins, but Mugabe forces a runoff, then agrees to share power.

2012
Elections postponed until this year.

Reported violence against civilians
▪ 1-10 incidents
● 11-25
● 26-50
● 51-112

JEROME N. COOKSON, NGM STAFF; SHELLEY SPERRY. SOURCES: CLIONADH RALEIGH, TRINITY COLLEGE DUBLIN; INFOMINE; USGS; HUMAN RIGHTS WATCH; ARMED CONFLICT LOCATION & EVENT DATASET; GADM DATABASE

An elderly man walks across a cornfield to the graves of four of his ten dead children. Under Mugabe's despotic leadership, health services have languished for the country's 12.6 million people.

NYASHA; UNAUTHORIZED GOLD MINER, MANICALAND PROVINCE

"I used to work in Harare in 2005. I lived in a home, but it was demolished. I was forced to come to the rural area; I had nothing else to do, so I would come to the river and look for gold — that's the only job."

THABO, 12, MATABELELAND SOUTH PROVINCE

"Our father died in 2005, and he lies in that grave on our fields. Our mother left us immediately. We used to sell firewood, but now the donkeys are thin; our cart has no tires. This year I am doing form one; I like going to school. When I grow up I want to be a teacher."

Morgan Tsvangirai, opposition leader and the current prime minister, has been arrested numerous times and once nearly beaten to death by Mugabe's henchmen.

100000000000000 RESERVE BANK OF ZIMBABWE 100000000000000
I promise to pay the bearer on demand
ONE HUNDRED TRILLION DOLLARS
for the Reserve Bank of Zimbabwe
100 000 000 000 000 HARARE
AA3640024

Monthly inflation reached 79.6 billion percent in November 2008, before foreign currencies were adopted, stabilizing retail prices.

withdrew from the race, and Mugabe declared himself the winner. Thabo Mbeki, then president of South Africa and a bafflingly uncritical Mugabe supporter, persuaded the two men to negotiate a power-sharing agreement. Mugabe retained control of the mines, the army, and the police and intelligence services—in other words, everything that ensured his continued dominance. Tsvangirai inherited the ministries of finance, education, health, environment—in other words, everything that ensured he couldn't run away with power.

A tenuous purgatory of waiting ensued—waiting for Mugabe's grip on power to ease, waiting for Mugabe to die (he was born in 1924). But in spite of rumored puffy ankles—cancer was one of the whispered speculations—Mugabe appeared as robust as ever. In 2010 *Foreign Policy* magazine named Mugabe the second worst dictator in the world, after North Korea's late leader Kim Jong Il. In 2012 the Washington, D.C.-based nonprofit organization the Fund for Peace ranked Zimbabwe fifth in its annual Failed States Index.

STILL, WHEN I ARRIVED in the country in mid-October 2012, things in the capital, Harare, seemed to be business as usual. An influx of diamond money—the 2006 discovery of diamonds in the east of the country has been called the biggest find of its kind—had lent a Botoxed sheen to the place: adoption of the U.S. dollar had simplified trade, new cars were on the roads, shops were full of South African imports, mansions mushroomed behind massive walls in the suburbs beyond State House.

But beneath the impression of regularity, disquiet remained. Ahead of tentatively scheduled elections in July 2013, ZANU-PF youth gangs were stirring in densely populated market centers; on international television ZANU-PF officials were blatantly threatening that they would not support a Tsvangirai win. At the same time headlines reported Tsvangirai's domestic intrigues, culminating in his recent marriage to Elizabeth Macheka, daughter of a ZANU-PF central committee guru. His position as a robust alternative to Mugabe seemed in question.

Meanwhile personnel from the Central Intelligence Organisation (CIO) were reportedly monitoring citizens' activities everywhere. "Yes, there are people who say I should watch out," Tafadzwa Muzondo, a 33-year-old Zimbabwean playwright told me. "But I have to do my duty. I am a citizen first. I am an artist second. And isn't it better to say at the end of your life that you tried to make a difference?" Muzondo had suggested we meet behind the National Gallery in the Harare Gardens. It was a steamy morning, and thunderstorms threatened, but we stayed out in the open, the better to spot any government-sponsored eavesdroppers, although I didn't see how a dried-up patch of lawn was going to do much to protect us against the CIO. But Muzondo had written a play that had provoked the government, and he was talking to a foreign writer, and to do either of those things in this place and at this time was to court trouble.

A concerned person can't help but keep track: In the decade from 2001 to 2011 official oppression has forced at least 49 Zimbabwean journalists into exile, the fifth worst record in the world. Within Zimbabwe's borders, scores of national and a few international human-rights activists, writers, and photographers have been intimidated or arrested, and one local cameraman, suspected of passing photographs of a beaten-up Morgan Tsvangirai to foreign media, was murdered in 2007. Since 2000 Tsvangirai has been arrested numerous times and once nearly beaten to death by Mugabe's henchmen. In theory, freedom of speech is protected. In practice, a series of imaginatively broad laws attempt to ensure silence. Regardless of when or how Mugabe leaves power, it's going to take his country a long time to recover from him.

"How do we intend to solve our violent history if we can't talk about it?" Muzondo asked. "You combine my poverty with my fear, with my silence—life is not worth living. They might as well just do mass killing." Zimbabweans are in the fearful position of watching themselves become the unspoken, the unheard—the mute, whose stories will be told only by foreign correspondents and Western aid workers. Once boasting the highest literacy rate in Africa—more than 90 percent—some predict that Zimbabwe's literacy rate will fall to 75 percent by 2020.

"We know this. Without our voice, we have no choice," Muzondo said. "Without choice, where are we? We're forever stuck in violence."

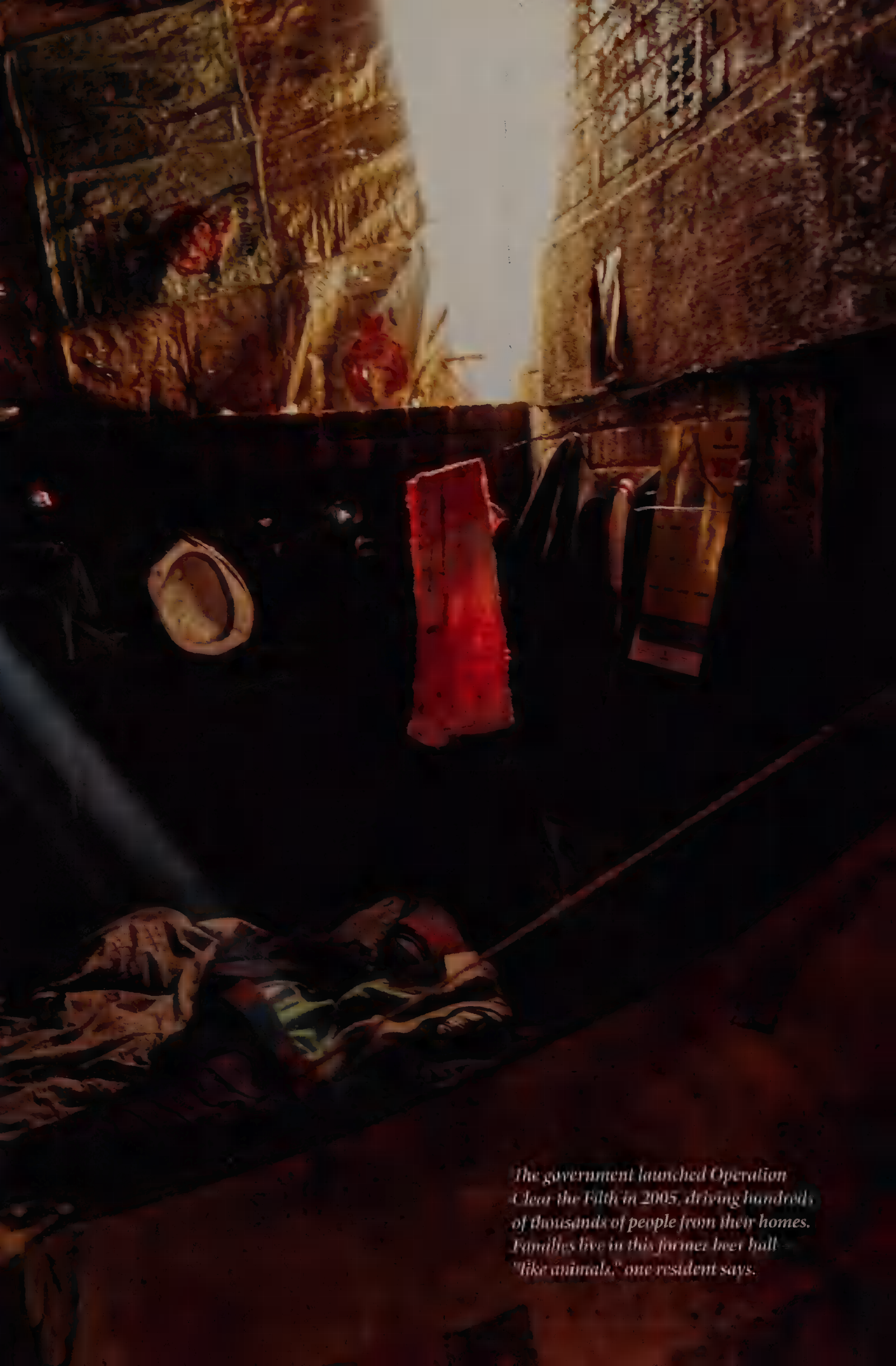
BUT ZIMBABWEAN WRITERS, artists, and playwrights haven't given up yet. Robust, sometimes mordantly funny, politically controversial novels, art exhibitions, and plays appear faster than CIO agents can object to them. In the past eight years Muzondo has written half a dozen plays dealing with pressing social and political issues. His latest—*No Voice, No Choice*—was banned in August 2012 after an enthusiastically received run around the country. "People were coming up to us afterwards and saying, 'We were scared of what would happen to us if someone noticed us watching your play, but then we noticed you were not scared of performing it. We felt more courageous because of your bravery.'"

The letter from the national authorities banning the play was Orwellian in its nonsensical doublespeak: "Please be advised that the Board of Censors read your Play Script and observed that the play is about discouraging youths participating in political violence… The play is inciteful and against the spirit of national healing." I turned the letter over, as if shaking up its words would make it more coherent, to say nothing of rectifying the unintentional pun (inciteful/insightful). "Someone felt uncomfortable with the truth," Muzondo said. "But that truth is this: We're all in this together. Neighbors have assaulted neighbors. Now we have to sit down together and face what it is we've done to one another. The government doesn't want us to have that conversation. But what if we did?"

This was never part of the political calculation. Eventually Zimbabweans might be brought together by their common bond of suffering and begin to insist on their own liberation. In fact, Mugabe seems to have deliberately turned so many ordinary Zimbabweans—soldiers and police officers, obviously, but also schoolboys ordered out of their classrooms to rape and torture—into perpetrators that there is now widespread fear a change of government might bring with it recrimination. "Victims of the political violence are afraid it will resurface with every election; perpetrators of the political violence are afraid it will end," Rutendo Munengami, an advocate for victims of rape, told me. "Everyone knows who the culprits are; they are our neighbors and officials. They are not hard to find. Those people are afraid of a government who will call them to account."

I MET MUNENGAMI and fellow activist Margaret Mazvarira in the garden of a quiet Harare restaurant a few mornings after my meeting with Muzondo. The sun appeared to take up the whole sky, and musasa tree pods cracked, showering seeds on the barely rain-softened earth. The two

Nine orphaned children live here with their elderly grandparents, eking out a living from the land. Some one million children in Zimbabwe have lost one or both parents to HIV/AIDS.



The government launched Operation Clear the Filth in 2005, driving hundreds of thousands of people from their homes. Families live in this former beer hall "like animals," one resident says.

ARC RESTAURANT
ARC RESTAURANT
Thrifty Market
Coca-Cola
ADUBE
R2
R1

A bustling street in Bulawayo belies the reality of a wrecked economy. Most Zimbabweans survive on informal trading or remittances sent home by relatives in the diaspora.

"Those so-called war vets raped so many women during liberation, but they don't want to talk about it. So we are going to talk about it. We are tired of being quiet."

—Rutendo Munengami

women spoke over each other, finishing each other's sentences, confirming the connecting braid of shared experience between them.

In the early hours of June 3, 2003, Munengami—whose husband was then an MDC councillor—was torn from her bed, her nursing nine-month-old son still in her arms. While soldiers looked on, Munengami told me, she was raped by a prominent ZANU-PF minister. Afterward, the minister drove her to a police station in Harare, where she and her son were dangled over a pit of acid while the soldiers decided whether or not to kill her. "They wanted to throw the baby to the ground," Munengami said. "They shouted, 'He will be the same as the father. He will want to give the country to the white man.'"

Mazvarira was abducted in 2000 from her home in Chivhu, a small town south of Harare, and raped by two ZANU-PF CIO officers after her 17-year-old daughter, an MDC organizer, was killed by a petrol bomb. Mazvarira contracted HIV from the assault. "They told me, 'You and your daughter are Tsvangirai's bitches.'" When Mazvarira went to the police station to report the attack, the officer in charge refused to hear her case. "The police are only ZANU-PF," she said.

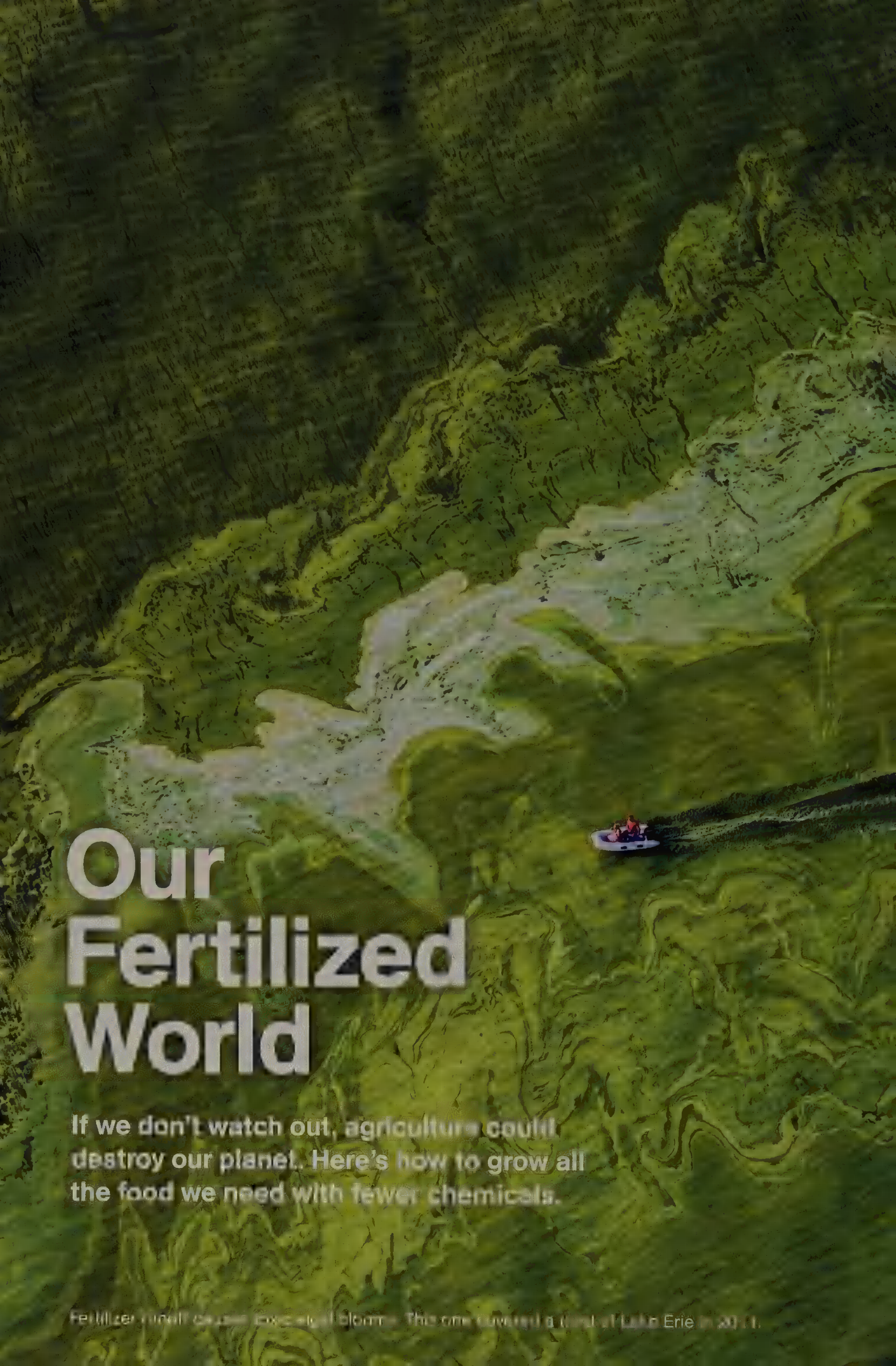
The two women are not placid about what happened to them, but what converted them from victims into activists is that they were never able to hold their attackers to account. "The government won't help us. No one can help us. It is up to us, ourselves, now. That is where we are." In 2009 Munengami launched Doors of Hope, a nonprofit organization that supports and speaks for victims of politically motivated rape. Doors of Hope now has 375 members from all over the country. "We are standing for women," Munengami said. "Those so-called war vets raped so many women during the liberation struggle, but they don't want to talk about it. So we are going to talk about it. Whether it's 1975, or now, we don't want this to continue. We have had enough. We are sick and tired of being quiet. Where has silence got us?"

In a nearby jacaranda tree, the call of a cape turtle dove echoed Zimbabwe's eternal lament, "My mother is dead, my father is dead, all my relatives are dead." From my recent travels across the country, I knew that organizations like Doors of Hope existed all over Zimbabwe. I had spoken to the director of Radio Dialogue, a small station in Bulawayo that had circumvented a ban on independent broadcasting by distributing cassettes and CDs to minibus drivers. I had spoken to survivors of political torture who had organized healing circles with their erstwhile attackers and were now running a nonprofit, Tree of Life, which had gone into scores of communities throughout the country holding workshops to help both victims and perpetrators recover from past political violence. I had spoken to the editors of Weaver Press in Harare, which still published brave, politically sensitive books, and I had picked up copies of poetry published by amaBooks in Bulawayo. I had spoken to artists and writers and doctors who were challenging the inevitability of a silent, violent future.

"I am like that tree," Mazvarira said suddenly, pointing toward the jacaranda. "I've had my branches cut, but I am not dead. I am attached to this soil, and it feeds my roots." She pushed her plate away. "Today I got to tell my story. I was heard. That is my rain." She leaned forward with a smile of the kind that can come only when there is still hope in a nearly hopeless place. "So please tell your world not to turn the page on us yet. Tell them to keep hearing us. We are still speaking." ☐

EDSON, VICTIM OF ELECTION VIOLENCE IN 2008, MASVINGO PROVINCE

"We didn't have any tool to fight. They took a 25 liter of petrol and started to spray all of our bodies. The whole room was a blaze of fire; we were in pain and agony. I was thinking I am gone forever, but due to God, see—I am still kicking."



Our Fertilized World

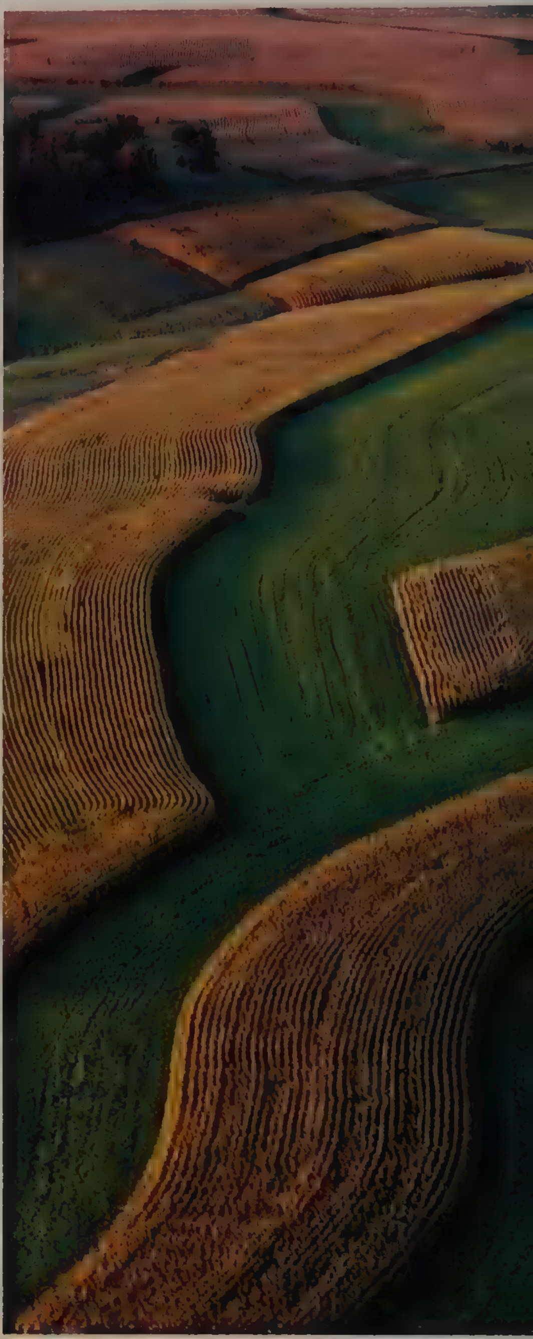
If we don't watch out, agriculture could destroy our planet. Here's how to grow all the food we need with fewer chemicals.

Fertilizer runoff causes toxic algal blooms. This one covered a third of Lake Erie in 2011.

When the mermaid show at Weeki Wachee Springs in Florida made its debut in 1947, the bathing beauties swam among waving fronds of eelgrass. Today algae fed by nitrogen fertilizer from farms and lawns crowd out many of the springs' native plants.

BY DAN CHARLES

PHOTOGRAPHS BY PETER ESSICK



N. Nitrogen. Atomic number seven. Unnoticed, untasted, it nevertheless fills our stomachs.

It is the engine of agriculture, the key to plenty in our crowded, hungry world.

Without this independent-minded element, disinclined to associate with other gases, the machinery of photosynthesis cannot function—no protein can form, and no plant can grow. Corn, wheat, and rice, the fast-growing crops on which humanity depends for survival, are among the most nitrogen hungry of all plants. They demand more, in fact, than nature alone can provide.

Enter modern chemistry. Giant factories capture inert nitrogen gas from the vast stores in our atmosphere and force it into a chemical union with the hydrogen in natural gas, creating the reactive compounds that plants crave. That nitrogen fertilizer—more than a hundred million tons applied worldwide every year—fuels bountiful harvests. Without it, human civilization in its current form could not exist. Our planet's soil simply could not grow enough food to provide all seven billion of us our accustomed diet. In fact, almost half of the nitrogen found in our bodies' muscle and organ tissue started out in a fertilizer factory.

Yet this modern miracle exacts a price. Runaway nitrogen is suffocating wildlife in lakes and estuaries, contaminating groundwater, and even warming the globe's climate. As a hungry world looks ahead to billions more mouths needing nitrogen-rich protein, how much clean water and air will survive our demand for fertile fields?

The nitrogen dilemma is most starkly visible in China, a country that loves its food and worries that supplies might run out. To the casual visitor, that anxiety seems misplaced. There's a feast, it seems, on every street. In a restaurant called San Geng Bi Feng Gang, on the outskirts of Nanjing, I watch with wonder as dishes parade by: steamed fish, fried mutton chops, chrysanthemum-leaf-and-egg soup, a noodle dish made from sweet potatoes, fried broccoli, Chinese yams, steaming bowls of rice.

"Did you always eat this well?" I ask Liu Tianlong, an agricultural scientist who's introducing me to farmers nearby.

His boyish smile fades, and for a second he looks grim. "No," he says. "When I was young,

To grow plentiful food crops, farms need more nitrogen than naturally occurs in the soil. Fertilizer runoff is minimized on this Wisconsin farm by planting strips of alfalfa between corn and soybeans.

you were lucky to get three bowls of rice."

Liu grew up in the aftermath of China's great famine, which lasted from 1959 to 1961 and killed an estimated 30 million people. Drought played a part, but the catastrophe was inflicted mainly by the whims of Chairman Mao. The Chinese leader's Great Leap Forward collectivized farming and forced peasants to turn their harvests over to a centralized bureaucracy.

The famine passed, but scarcity continued until the late 1970s, when farmers regained control of their own harvests. "Within two years, almost overnight, food was in surplus," recalls Deli Chen, who witnessed those reforms as a boy in a small rice-growing village in Jiangsu Province. Chen is now a soil scientist at the University of Melbourne in Australia.

Yet China's newly entrepreneurial farmers ran into another barrier: the limits of their land. As the country's population grew by an astounding 300 million people between 1970 and 1990, China's traditional agriculture struggled to keep up.

Song Linyuan, an elderly but spry farmer in a village northwest of Nanjing, recalls how he once kept his 1.3 acres of cropland as fertile as possible, composting household waste and spreading manure from his pigs and chickens. In all, his efforts added perhaps a hundred pounds of

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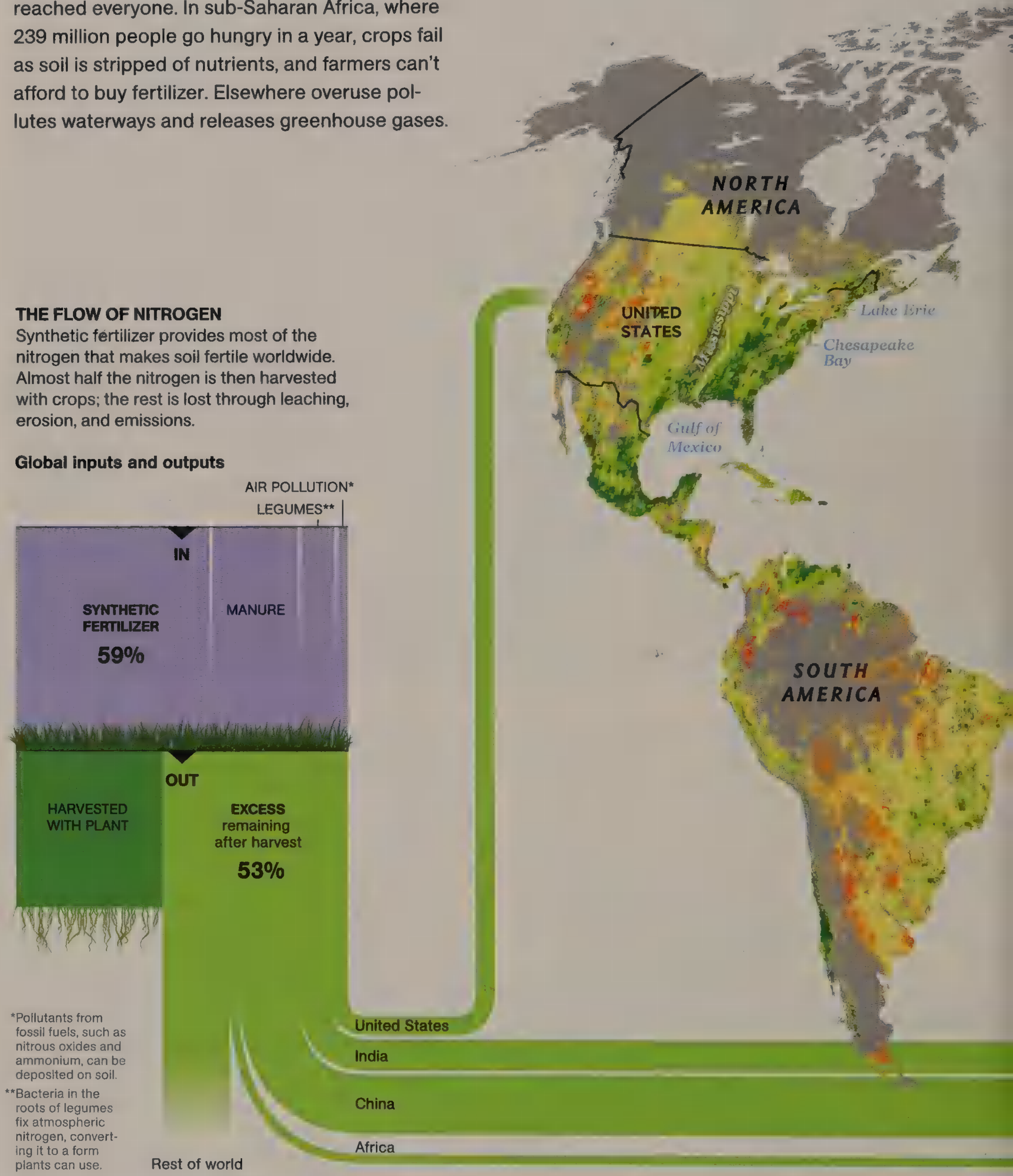
Dan Charles is NPR's food and agriculture correspondent. Peter Essick frequently photographs the impact of development on our environment.

Feast or Famine

Nearly half the people on the planet wouldn't be alive if not for the abundant food made possible by nitrogen fertilizer. Yet its benefits have not reached everyone. In sub-Saharan Africa, where 239 million people go hungry in a year, crops fail as soil is stripped of nutrients, and farmers can't afford to buy fertilizer. Elsewhere overuse pollutes waterways and releases greenhouse gases.

THE FLOW OF NITROGEN
Synthetic fertilizer provides most of the nitrogen that makes soil fertile worldwide. Almost half the nitrogen is then harvested with crops; the rest is lost through leaching, erosion, and emissions.

Global inputs and outputs

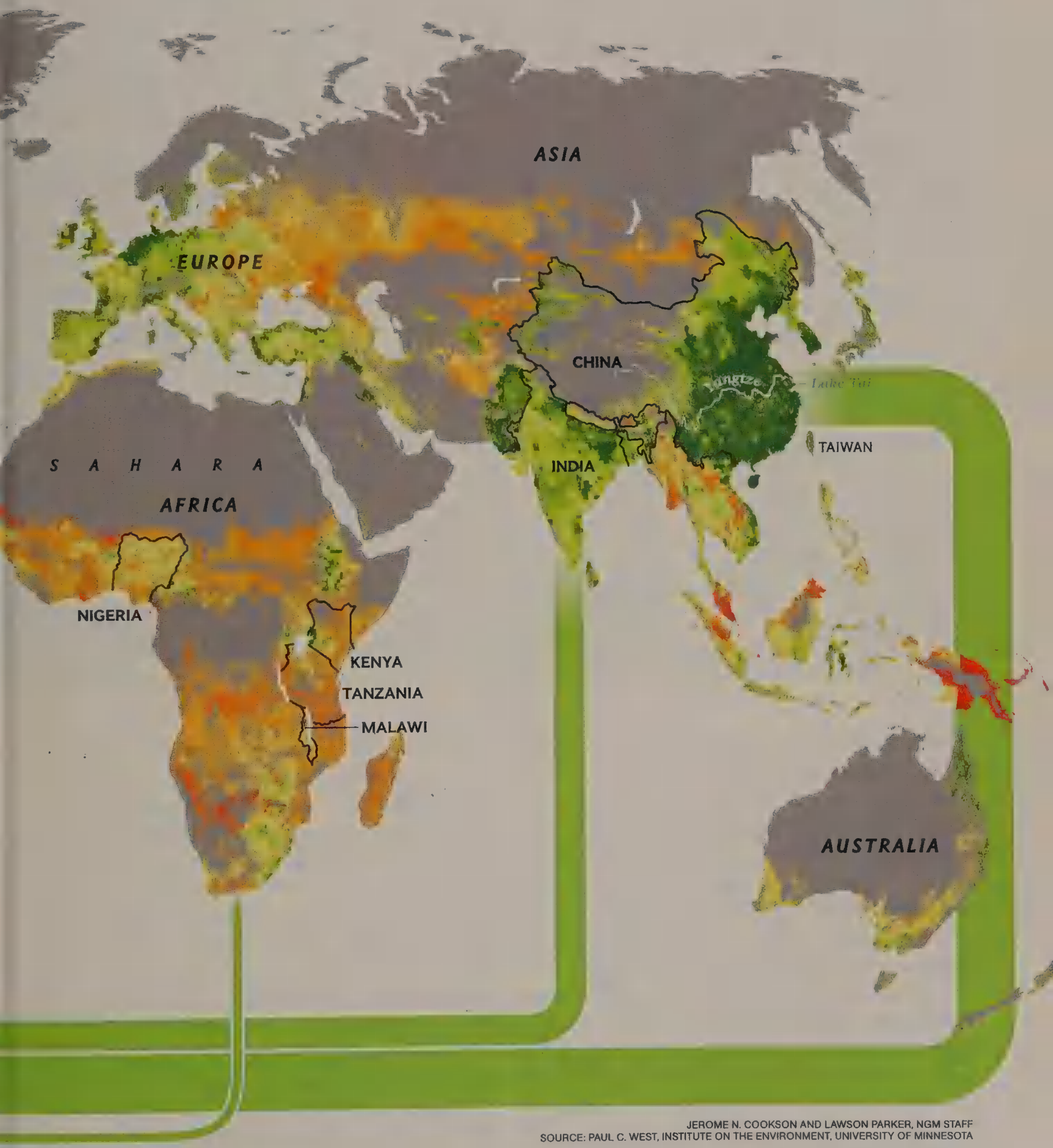


*Pollutants from fossil fuels, such as nitrous oxides and ammonium, can be deposited on soil.

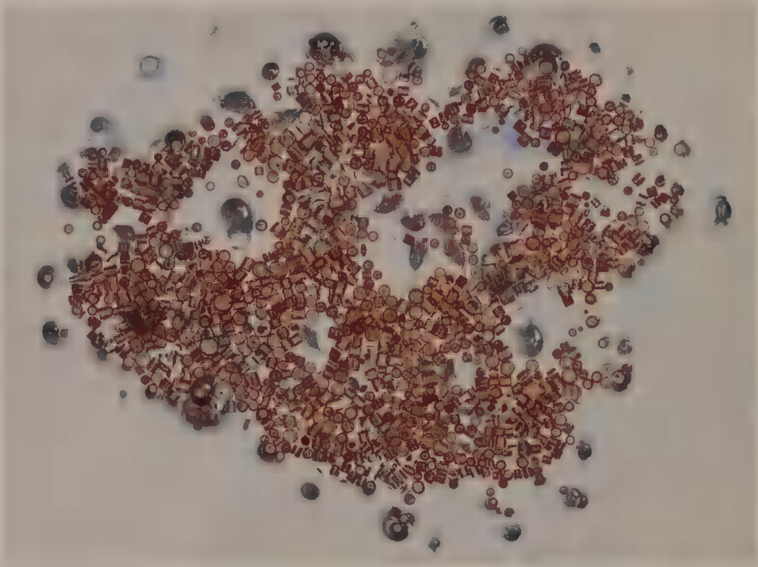
**Bacteria in the roots of legumes fix atmospheric nitrogen, converting it to a form plants can use.

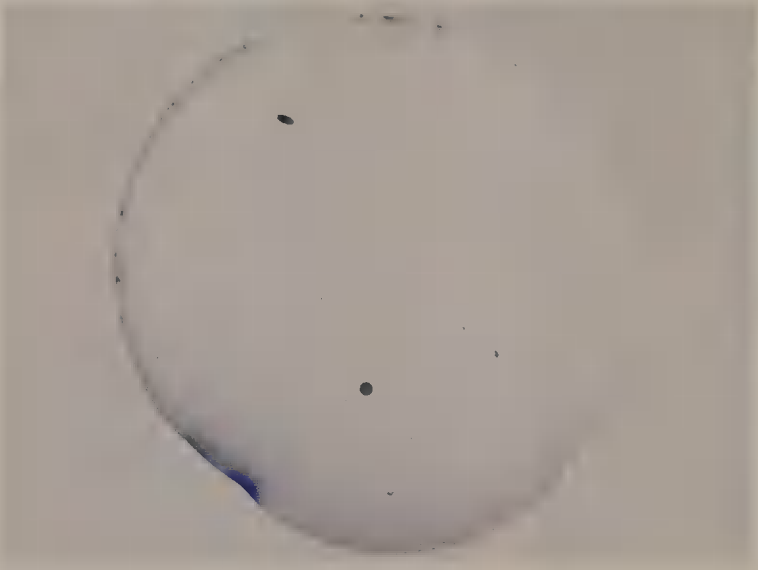
TOO MUCH OF A GOOD THING

Almost half the nitrogen fertilizer applied to major crops is not taken up by plants. Most of the excess is from wheat, rice, and corn farms in China, India, and the United States.


Average annual nitrogen balance,
pounds per acre
Deficiency
Excess
-200
0
220
▨ Little or no cropland
Zero means the crop used exactly the amount of nitrogen applied. The ideal range varies due to local conditions.
ASIA
EUROPE
CHINA
Yangtze
Lake Tai
TAIWAN
INDIA
SAHARA
AFRICA
NIGERIA
KENYA
TANZANIA
MALAWI
AUSTRALIA

JEROME N. COOKSON AND LAWSON PARKER, NGM STAFF
SOURCE: PAUL C. WEST, INSTITUTE ON THE ENVIRONMENT, UNIVERSITY OF MINNESOTA



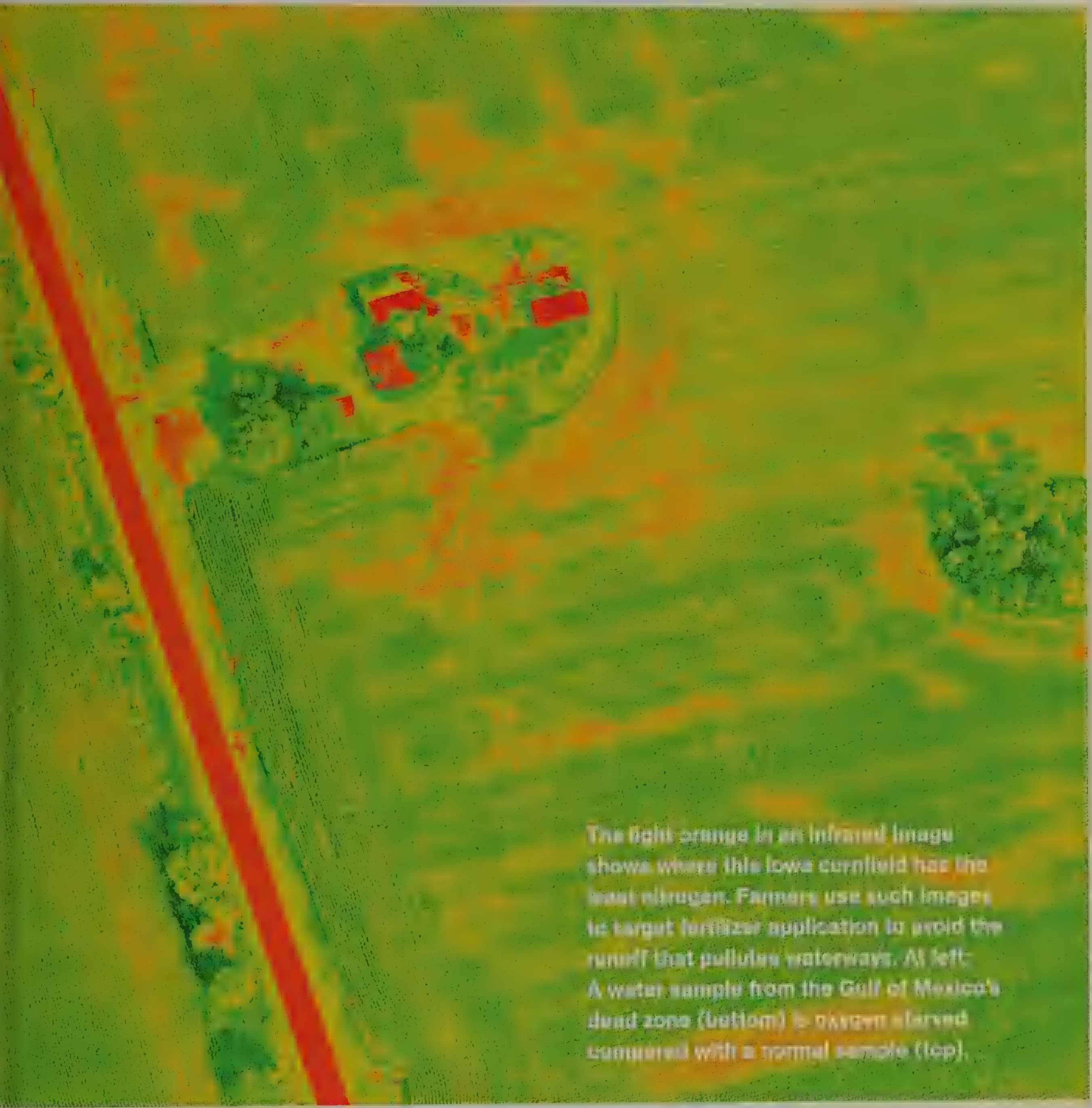


nitrogen per acre of land each year. He harvested 2,600 to 3,300 pounds of rice per acre.

That's a respectable harvest, a better yield than in many parts of the world. But now he gets more than twice that: 7,200 pounds per acre. It's a harvest many farmers can only dream of.

The difference? "Better fertilizer," he says. We're sitting in a shop surrounded by farmers. Song's answer provokes a loud discussion. Some agree that fertilizer was key; others say better seeds were more important. In reality the two technologies are intertwined. The high-yielding varieties of rice and wheat that breeders created in the 1950s and 1960s could reach their full potential only if they got more nitrogen.

The Chinese government made sure those crops were well fed. Between 1975 and 1995 it built hundreds of nitrogen factories, quadrupling the country's manufacture of fertilizer and turning China into the world's biggest producer. Song now spreads about five times as much nitrogen as before, saturating his fields with urea—a dry form of nitrogen—by casting handfuls of the snow-white granules across green shoots. This adds up to 530 pounds of nitrogen per acre. Farmers who grow vegetables use even more; some spread a ton of nitrogen, or even two, on each hectare (2.47 acres). Few of them think they're doing anything harmful. "No, no pollution," says Song, when asked



The light orange in an infrared image shows where this Iowa cornfield has the least nitrogen. Farmers use such images to target fertilizer application to avoid the runoff that pollutes waterways. At left: A water sample from the Gulf of Mexico's dead zone (bottom) is oxygen starved compared with a normal sample (top).

about the environmental effects of fertilizer.

Scientists tell a different story. "Nitrogen fertilizer is overused by 30 to 60 percent" in intensively managed fields, says Xiaotang Ju, of the China Agricultural University in Beijing. "It's misuse!" Once spread on fields, nitrogen compounds cascade through the environment, altering our world, often in unwelcome ways. Some of the nitrogen washes directly from fields into streams or escapes into the air. Some is eaten, in the form of grain, by either humans or farm animals, but is then released back into the environment as sewage or manure from the world's growing number of pig and chicken farms.

Deli Chen recalls catching fish as a boy. "The river was so clean. You could see right through it," he says. By 1980 "you couldn't see the fish anymore." The cloudiness came in part from proliferating phytoplankton, a symptom of water that's eutrophic, or overloaded with nutrients. A recent national survey of 40 lakes in China found that more than half of them suffered from too much nitrogen or phosphorus. (Fertilizer containing phosphorus is often to blame for algal growth in lakes.) The best known case is Lake Tai, China's third largest freshwater lake, which regularly experiences huge blooms of toxic cyanobacteria. A spreading bloom in 2007 contaminated water supplies for two million people in the nearby city of Wuxi. Excess nutrients are

DAVID LIITTSCHWAGER (LEFT, BOTH); NDVI PROCESSING BY BILL STOCKS (RIGHT)

Workers at a cooperative farm near Shanghai scatter fertilizer across fields of winter wheat. China is the largest producer and user of fertilizer in the world. Reluctant to limit fertilizer because of the country's history of famine, China overuses nitrogen by up to 60 percent.

Chickens provide the fertilizer on this Pennsylvania farm. The mobile coops are relocated daily to distribute manure evenly so that it won't drain into the Chesapeake Bay.

Can organic methods feed the world's most populous country? Zhu Zhaoliang laughs out loud at the question.

damaging fisheries in China's coastal areas in the same way that fertilizer runoff flowing down the Mississippi has destroyed fisheries in the Gulf of Mexico: by creating dead zones in which algae and phytoplankton bloom, die, and decompose, using up oxygen and suffocating fish.

Our demand for food, to be sure, isn't solely to blame. The combustion that drives cars and electric generators releases nitrogen oxides into the atmosphere, and when those compounds return to Earth in drops of rain, they also act as fertilizer. (This accounts for about a quarter of the nitrogen load in Lake Tai.) But worldwide, commercial fertilizer adds up to 70 percent of the nitrogen that human activity produces every year.

Nitrate-eating bacteria in the soil can convert these disruptive forms of nitrogen back to the original, environmentally benign source that makes up nearly 80 percent of our atmosphere. But even this process is a mixed blessing, as the bacteria also release small amounts of nitrous oxide, a powerful greenhouse gas. "To solve this nutrient-overload problem, it is my dream," says Xiaotang Ju, who is part of China's "nitrogen family," a loose network of scientists devoted to this herculean task. The patriarch of the cause, Zhu Zhaoliang, startled a conference of China's ruling party in 1998 with a lecture about the dangers of agricultural pollution. China's president at the time, Jiang Zemin, responded that he didn't realize agriculture could pollute so seriously.

These scientists have begun working with small groups of farmers, showing them that less fertilizer doesn't shrink their harvests and can actually fatten their wallets. They're promoting the use of compost and teaching farmers to apply synthetic fertilizer when and where the plants actually need it. But they admit they've made little progress. The biggest obstacle is that most Chinese farmers are part-time. They aren't interested in saving a few yuan by cutting back on fertilizer. It's more important to save time and keep their city jobs, so they apply fertilizer quickly but inefficiently.

And fear of food scarcity still haunts the Chinese imagination, outweighing concerns about the environment. Huang Jikun, director of the Center for Chinese Agricultural Policy, frequently tries to convince government officials that their worries are misplaced. "I tell them, China is more food secure than it has been for 5,000 years!" he says. But for officials and farmers alike, applying less fertilizer seems like tempting fate, risking a disastrous shortfall.

It's likely that China—and the rest of the world—will use more nitrogen in the years to come, not less. Populations continue to expand, and meat is growing more popular. Feeding pigs or cattle demands several times more agricultural production than does using that grain to directly nourish people. "If Chinese change their diet to be like yours [in the West], the environmental pressure will be very high," says Xiaotang Ju somberly. "We have to tend to this problem. Otherwise it will be really big."

THERE'S A GLIMPSE of a solution on a farm just outside the small town of Harlan in western Iowa. Here 90 cattle graze on green pasture, and a few hundred pigs root about in beds of straw, surrounded by fields of alfalfa, corn, soybeans, oats, and barley.

Ron and Maria Rosmann spread no nitrogen fertilizer on these fields, at least not the kind that comes from factories. Instead, it's added biologically, by nitrogen-fixing bacteria that live in nodules on the roots of legume crops like soybeans, alfalfa, and a cover crop of clover that Ron Rosmann plants in the fall, only to till it back into the soil before he plants corn in the spring. Some of that nitrogen is captured in the corn, which he feeds to the pigs. Most of that ends up in manure, which goes back onto his fields, and the cycle starts all over again. Rosmann, unlike many other organic farmers, doesn't buy manure from neighbors.

"One of our goals has been to maintain a closed system," he says. "We are a model for what organic farming should be like."

We wade into one cornfield. The stalks tower over our heads. "Look at this corn," Rosmann exults. "We could have 200-bushel corn right here. A lot of naysayers will say, You organic guys can't feed the world. I say, That's not true. Look at this crop!"

Though much of the world suffers from the ill effects of too much nitrogen, most African farmland doesn't have enough. The *Faidherbia albida* tree offers a sustainable solution. Its leaves fertilize crops, as do bacteria in nodules on the tree's roots.

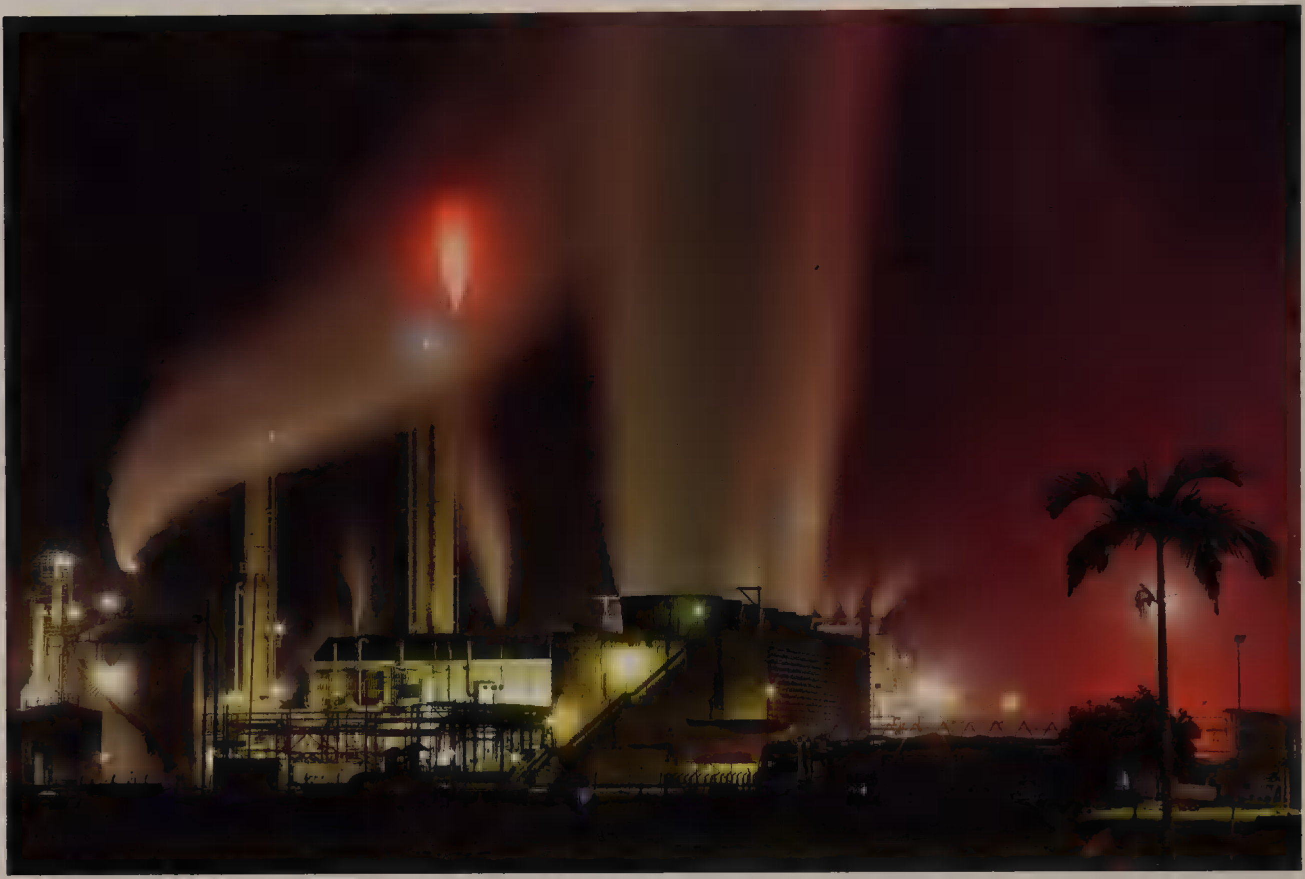
Yet Rosmann's methods carry their own cost. Farming this way takes more work, for one thing. And biology works more slowly than a nitrogen factory. The crops that build up the soil's store of nitrogen, like alfalfa, don't bring in as much money, or feed as many people, as nitrogen-hungry corn.

That's not necessarily a problem for North America. The United States, with six times as much arable land per person as China, has the luxury of planting less-productive crops that protect the environment, if people are willing to pay for them. That setup works for Rosmann; he gets a small payment from the government, part of an environmental subsidy program, and sells his organic crops for premium prices.

But will everyone pay those prices? Could his methods feed the world's most populous country? Zhu Zhaoliang, in his office at the Institute of Soil Science in Nanjing, laughs out loud at the question. "Organic farming is not a solution for China," he says flatly.

Yet there may be a middle ground—excellent harvests with reduced nitrogen pollution—and some of the world's most intensely studied fields are pointing the way toward it. Those fields, each exactly a hectare in size, are part of Michigan State University's Kellogg Biological Station, near Kalamazoo. For 20 years these fields have been growing corn, soybeans, and wheat in exactly the same rhythm, providing a side-by-side comparison of four different ways to farm, ranging from mainstream to organic. Everything that enters or leaves the fields is carefully measured: rainfall, fertilizer, nitrous oxide emitted from the soil, water that leaches into groundwater, and finally the harvest.

Michigan State's Phil Robertson, who helped



This Nigerian plant is the only factory in sub-Saharan Africa producing low-cost urea fertilizer. Some scientists say fertilizer overuse elsewhere should not prevent farmers in Africa from getting access to its crop-boosting benefits.

set up this long-running experiment, takes me on a tour of the fields. He's itching to reveal some new and "quite amazing" data. Each field planted according to standard plowing and fertilizer recommendations released 610 pounds of nitrogen per acre into Michigan's shallow groundwater over the past 11 years. "So about half of the fertilizer that's added we lose," Robertson says. This loss is much less than what's common in China. Yet when multiplied by tens of millions of acres of American cropland, it's enough to produce polluted groundwater, a nutrient-loaded Mississippi River, and an enormous dead zone in the Gulf of Mexico.

The organic fields in Robertson's experiment, which received no commercial fertilizer or manure, lost only a third as much—but those fields also produced 20 percent less grain. Intriguingly, the "low input" fields, which received small amounts of fertilizer but were also planted with winter cover crops, offered the best of both worlds: Average yields were about as high as those from the conventional fields, but nitrogen leaching was much reduced, almost to the level of the organic fields. If America's farmers could cut their nitrogen losses to something close to this level, Robertson thinks, restored wetlands and revived small streams could clean up the rest. As in China, though, many farmers find it hard to change. When a family's livelihood is at stake, it may seem safer to apply too much fertilizer rather than too little. "Being a good steward currently has economic consequences that are unfair," says Robertson.

VIEWED FROM AFRICA, the problem of overusing commercial fertilizer seems like a luxury. African farmers use meager quantities of the

Everyone agrees: African farmers need more nitrogen. But there's a raging, bitter debate over where to get it.

stuff—just seven pounds per acre on average. Alternative sources, such as manure or legume crops, are scarce as well.

Many in Africa's rural villages have fallen into a set of vicious circles. Fearing hunger, they concentrate on crops like rice or corn that deliver maximum calories but that tend to strip nutrients from the soil. Depleted land delivers increasingly poor harvests, leaving farmers too financially strapped to afford fertilizer, from whatever source. And since there is little demand for commercial fertilizer, no one makes it locally, so it's imported and expensive.

According to many experts, African soils are being mined. The natural reservoirs of fertility—nutrients stored in the organic matter of decomposing roots and leaves from previous centuries—are shrinking as farming extracts more nitrogen, phosphorus, and potassium every year than it replaces. This leaves the land progressively less able to feed the people who depend on it—"a scenario for disaster over the long run," according to the World Bank.

The average grain yield in sub-Saharan Africa is about 900 pounds per acre, just one-fifth the average in China. Nearly everyone who's looked at the situation agrees: African farmers need more nitrogen to improve their harvests and their lives. But there's a raging, bitter debate over where they should get it.

Some, like Jeffrey Sachs at Columbia University's Earth Institute, believe that increasing agricultural production demands more commercial fertilizer, and if poor African farmers can't afford it, then wealthier nations should provide it. In 80 villages across ten different African countries, Sachs's Millennium Villages Project passes out bags of improved seeds and fertilizer. And the project's having a big impact, according to its own data. In the millennium villages of Tanzania, Kenya, and Malawi, grain production doubled almost immediately.

In 2006 the government of Malawi started providing cheap fertilizer to about half the nation's farmers. Production of corn doubled—although good rains get much of the credit. These programs, however, are haunted by doubts about the future. Fertilizer subsidies were tried in many African countries during the 1970s and 1980s but fell out of favor because they were expensive and plagued by corruption. Malawi's current subsidy program is already in trouble: The government is running out of money to pay for it.

"Africa cannot afford massive amounts of fertilizer," says Sieglinde Snapp, a crop scientist at Michigan State University. A more sustainable approach, she says, is greater reliance on nitrogen-fixing plants. Thousands of farm families in Malawi have begun growing nitrogen-adding pigeon peas and peanuts on their land, replacing some of their corn. It's part of a ten-year-old experiment begun by local hospitals, farmers, and agricultural researchers.

Because peas made the soil more fertile, the next season's corn harvest was larger—more than making up for the fact that less land was being planted with corn. "Less corn is more corn," says Snapp. Plus that bonus crop of pigeon peas provided more nutritious, protein-rich meals. "But it didn't happen overnight," says Snapp. "It took education on how to use the legumes. It was 20 years of work, with a hospital involved. People changed their recipes."

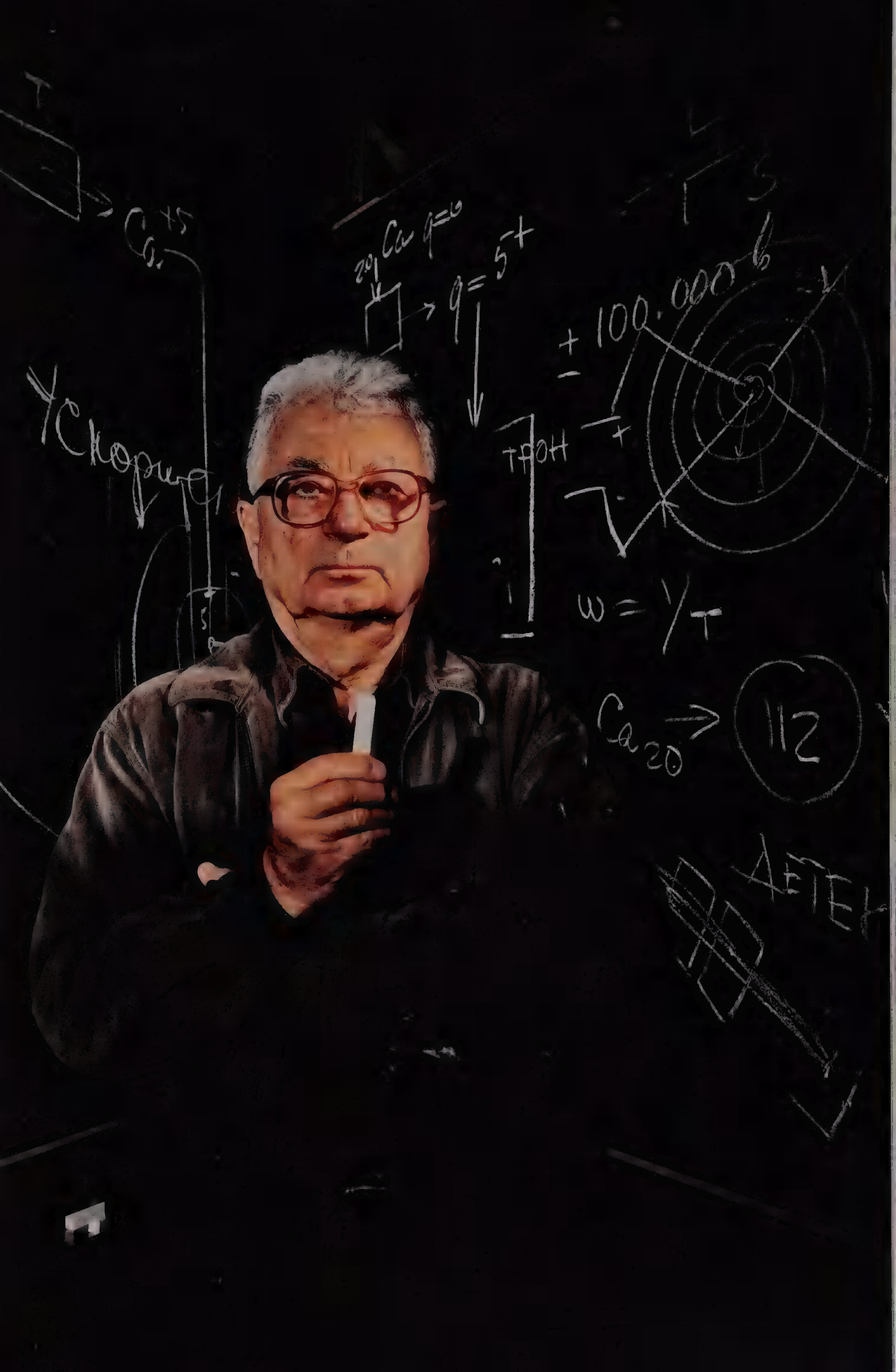
Snapp's observation—that acquiring and conserving nitrogen in the future will take considerable know-how and patience—is echoed by many people engaged in this worldwide quest. Asked what Chinese agriculture needs most, soil scientist Zhu Zhaoliang responds quickly, "More scale"—meaning larger, more skillfully managed farms. Ron Rosmann, in Iowa, explains that farming without added nitrogen "takes more management, more labor, more attention to detail. We're kind of fanatics."

A century ago, when chemist Fritz Haber first learned how to capture nitrogen from the air, synthetic fertilizer seemed like an easy shortcut out of scarcity, delivering a limitless supply of agriculture's most important nutrient. Yet new limits on nitrogen are appearing. This time the innovations that save us—and our planet—may not be invented in a chemistry laboratory. Instead they may come from farmers and fields in every corner of the world. □

	118 E	119 L	120 E
121 M	122 E	123 N	124 T
125 H	126 U	127 N	128 T
129 E	130 R	131 S	

All the elements found in nature—the different kinds of atoms—were found long ago. To bag a new one these days, and push the frontiers of matter, you have to create it first.

Yuri Oganessian, chalk in hand, heads a Russian team that is credited with creating 11 new heavy elements.


Ca
Ускори
20 Ca q=0
q=5+
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ТРОН
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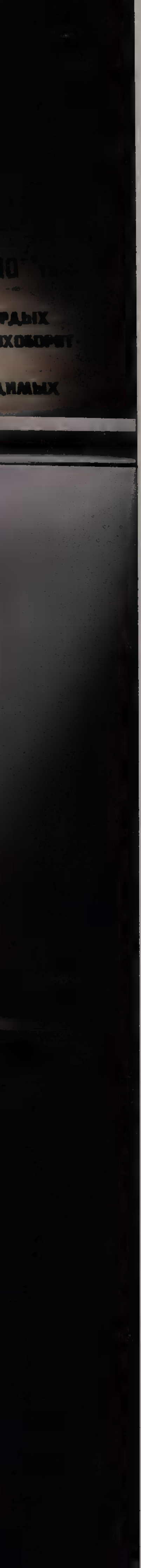
ДЕТЕК

СТОЙ
НАПРЯЖЕНИЕ
У-400
У-400
Рабочий вакуум
Система вывода

The periodic table, invented in 1869 by Dmitry Mendeleyev, looms over old parts and tools in a quiet corner at the Flerov Laboratory of Nuclear Reactions in Dubna, Russia. Physicists there add new elements to the table by fusing old ones.



By Rob Dunn

Photographs by Max Aguilera-Hellweg

119

LAST OCTOBER 22, at 9:29 a.m., a bell rang in the main office of Yuri Oganessian's lab in Dubna, north of Moscow. In a cramped warren partitioned by bookshelves and whiteboards, 12 nuclear physicists sat at desks stacked high with papers or strewn with snacks. Across the hall, a rebuilt but venerable cyclotron was flinging calcium atoms against a bit of foil at 67 million miles an hour. The chime of the little bell signaled that one of those collisions had worked: A new atom was born. At that moment it was the only atom of element 117 on Earth, and only the 19th ever to exist. The others had also been made in this lab, and all had quickly vanished. After a fraction of a second, this one was gone too.

Dubna, which sits on the Volga River, was carved out of a forest as a new city of science after World War II. Georgy Flerov, who had helped launch the Soviet Union's nuclear weapons research, founded the laboratory that Oganessian later took over. Early in the war Flerov had noticed that the flow of articles about radioactive elements from American and German scientists had suddenly stopped. He suspected they were building atomic bombs, and he wrote to Soviet leader Joseph Stalin in April 1942. Stalin charged Russian physicists with building a bomb too. For his part Flerov was rewarded with a car, a dacha, and, most significant, the lab in Dubna. There he focused on the hunt for new elements.

Everything you know and love on Earth, and everything you don't, is built of elements—the different types of atoms. They're billions of years old, most of them, scattered into space by the big bang or exploding stars, then incorporated into the newborn Earth, then endlessly recycled as they moved from rock to bacteria, president, or squirrel. In the late 1800s another Russian, Dmitry Mendeleyev, tried to make sense of them all, grouping them by mass and other attributes in his periodic table. Later scientists traced Mendeleyev's order to the structure of atoms. Each element got a number: the number of protons in its atomic nucleus.

By 1940, researchers had discovered everything that is durable and ancient on this Earth, right up to uranium, element 92. They'd filled in every gap Mendeleyev had left. But they weren't finished. Beyond uranium lies a world of possibilities—elements too radioactive and unstable to have survived billions of years. To explore that world, you have to create it first.

The first steps of creation changed more than just the periodic table. In 1941, after Glenn Seaborg and his colleagues at the University of California, Berkeley produced element 94, plutonium, Seaborg was promptly recruited to the Manhattan Project—Flerov was right. After helping to engineer the plutonium bomb that was dropped on Nagasaki, Japan, ending the war, Seaborg returned to Berkeley. He continued to make new elements, with less dramatic applications—smoke detectors, for instance—or none at all. By 1955

THE NEW AGE OF EXPLORATION is a yearlong series of articles celebrating *National Geographic* at 125.

his team had gotten as far as element 101. He named it mendelevium.

For a time it seemed Mendeleyev's table might end there, with his namesake. The protons in an atomic nucleus are always trying to tear it apart; their positive electric charges repel one another. Neutrons—electrically neutral particles that outnumber the protons—help bind the nucleus together. But that binding force works only at extremely close range. It weakens sharply as the size of the nucleus increases. So there has to be a final box on the periodic table, a maximum size beyond which an atom won't be stable even fleetingly, as a sort of chemical mayfly. With mendelevium, which has a half-life of 51.5 days, researchers seemed to be getting close.

The Berkeley team pressed on regardless, rivaled by the Flerov Laboratory of Nuclear Reactions at the Joint Institute for Nuclear Research in Dubna. From 1965 to 1974, Berkeley claimed to have produced elements 102, 103, 104, 105, and 106—but so did Dubna. Those mayflies died within hours. The dispute over who made them first got ugly anyway, heightened perhaps by the Cold War. In the end, compromise prevailed: Element 105 was named dubnium and element 106 seaborgium. Nuclear war was averted.

Meanwhile theorists had given new purpose to the quest. A very large nucleus might be surprisingly stable, they decided, if it had "magic numbers" of protons and neutrons—enough to just fill the discrete shells the particles occupy. That insight, if right, would change everything. It would mean that maybe, just maybe, there was an "island of stability" beyond the horizon, where monstrously heavy elements with 114, 120, or 126 protons might last minutes, weeks, or even thousands of years. That fuzzy dream of a new world made the journey suddenly more compelling. It was around this time that Oganessian joined Flerov's lab.

ON THE "ISLAND OF STABILITY," MONSTROUSLY HEAVY ELEMENTS MIGHT LAST THOUSANDS OF YEARS.

ONE EVENING LAST FALL IN DUBNA my translator and I knocked on the door of Oganessian's modest yellow house on Flerov Street. Snow clouds hung low overhead; rooks hopped around streetlights. Oganessian loaned us slippers and led us to his dining room, where he poured tea. When the tea was done, we had coffee, then homemade Armenian wine. We talked about American folk music, our children, and our travels. After some time we turned to Oganessian's journey to the island of stability.

When he was a young man and the island first captured his imagination, it seemed impossible to reach. The Berkeley and Dubna labs had gotten as far as element 106 by slinging light nuclei against heavy ones with such force that they fused into a single superheavy nucleus. But beyond 106 the collisions were so energetic they were blowing the new nucleus apart

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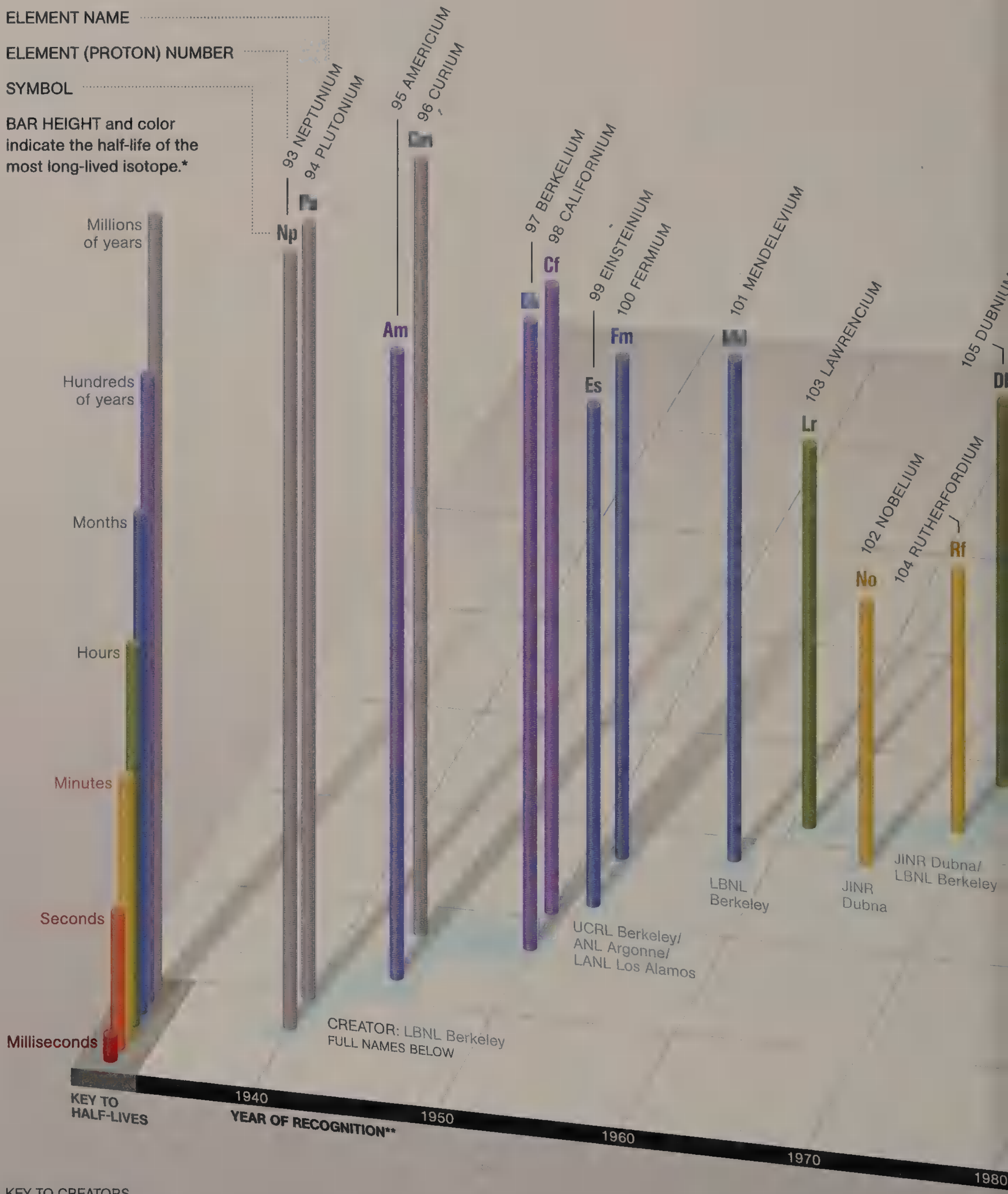
Ecologist Rob Dunn wrote about leaves in the October 2012 issue.
Max Aguilera-Hellweg photographed robots for the magazine in August 2011.

Four blue magnets in Dubna focus calcium ions into a thin beam that travels at a tenth the speed of light. When the calcium rips into a target bearing a much heavier element, the two kinds of atoms may fuse, forming a new, superheavy atom.

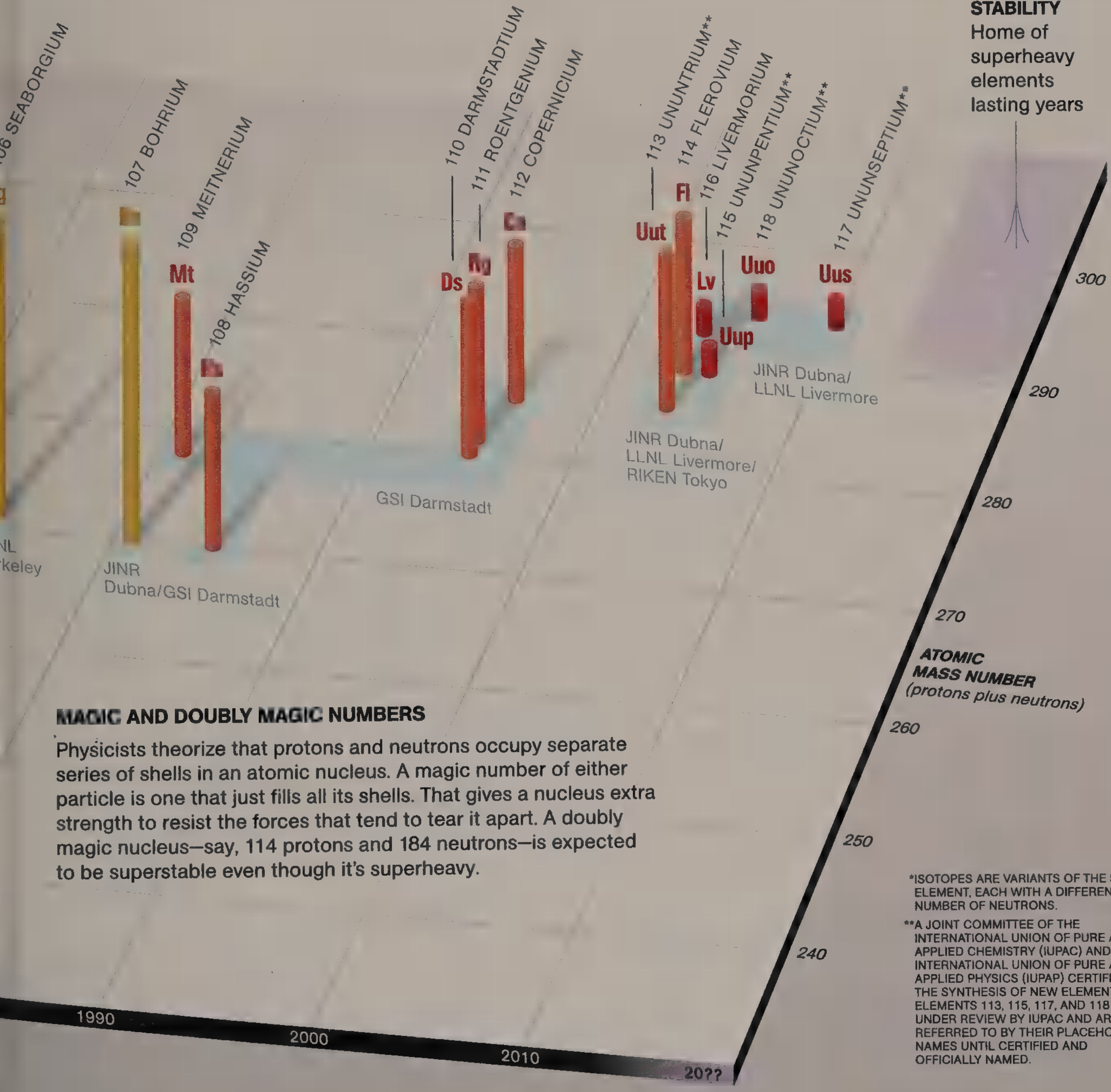


KEY TO CREATORS

LBNL Berkeley	Lawrence Berkeley National Laboratory, Berkeley, California
UCRL Berkeley	University of California Radiation Laboratory, Berkeley, California
ANL Argonne	Argonne National Laboratory, Argonne, Illinois
LANL Los Alamos	Los Alamos National Laboratory, Los Alamos, New Mexico
JINR Dubna	Joint Institute for Nuclear Research, Dubna, Russia
GSI Darmstadt	GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany
LLNL Livermore	Lawrence Livermore National Laboratory, Livermore, California
RIKEN Tokyo	RIKEN Nishina Center for Accelerator Based Science, Tokyo, Japan

TWENTY-SIX NEW ELEMENTS

Over the past 73 years scientists have probed the frontiers of the atomic nucleus, synthesizing heavier elements one by one. The first step beyond uranium, the heaviest natural element, was neptunium, number 93 in the periodic table. The synthetic atoms are all radioactive: They decay into lighter elements, sometimes within milliseconds. In general, the heavier the element, the shorter its half-life. For decades researchers have been crossing a sea of short-lived elements in quest of the "island of stability," where "magic numbers" of protons and neutrons might combine to make superheavy atoms that last long enough to be studied.



ISLAND OF STABILITY
Home of superheavy elements lasting years

MAGIC AND DOUBLY MAGIC NUMBERS

Physicists theorize that protons and neutrons occupy separate series of shells in an atomic nucleus. A magic number of either particle is one that just fills all its shells. That gives a nucleus extra strength to resist the forces that tend to tear it apart. A doubly magic nucleus—say, 114 protons and 184 neutrons—is expected to be superstable even though it's superheavy.

*ISOTOPES ARE VARIANTS OF THE SAME ELEMENT, EACH WITH A DIFFERENT NUMBER OF NEUTRONS.

**A JOINT COMMITTEE OF THE INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY (IUPAC) AND THE INTERNATIONAL UNION OF PURE AND APPLIED PHYSICS (IUPAP) CERTIFIES THE SYNTHESIS OF NEW ELEMENTS. ELEMENTS 113, 115, 117, AND 118 ARE UNDER REVIEW BY IUPAC AND ARE REFERRED TO BY THEIR PLACEHOLDER NAMES UNTIL CERTIFIED AND OFFICIALLY NAMED.

JOHN TOMANIO, NGM STAFF; TONY SCHICK
CONSULTANTS: PAUL KAROL, CARNEGIE MELLON UNIVERSITY; ROGER HENDERSON, LAWRENCE LIVERMORE NATIONAL LABORATORY
SOURCES: INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY; NATIONAL NUCLEAR DATA CENTER, BROOKHAVEN NATIONAL LABORATORY

On our digital editions, explore a gallery of elements and see how they're created.

before it even formed. In 1974 Oganessian proposed that slightly heavier projectiles and lighter targets might make for gentler, more fruitful collisions. A lab in Darmstadt, Germany, seized on the idea to make elements 107 through 112. Oganessian's day was still a quarter century away.

The Dubna lab went through hard times. Flerov died in 1990; the Soviet Union collapsed in 1991. The lab went months without being able to pay its researchers. They gathered mushrooms in the forests; they fished the Volga. Oganessian was in charge by then. He could have set a course toward more practical goals. He decided instead to charge full steam ahead toward element 114—the near shore of the island of stability.

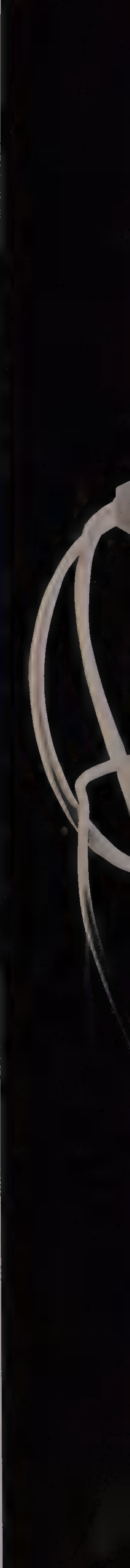
To make element 114, Oganessian would sling calcium (with 20 protons) at plutonium (with 94). His cyclotron could handle that. But he needed rare isotopes of calcium and plutonium, stuffed with enough extra neutrons to bind 114 protons. He persuaded American physicists at the Lawrence Livermore National Laboratory in California, who just a few years earlier had been his rivals, to surrender 20 milligrams of plutonium. The plan was for the cyclotron to shoot a beam of calcium at one tenth the speed of light into foil coated with the precious plutonium. Among the trillions of atoms spraying out the other side—the foil was thinner than hair—Oganessian expected at most one atom of 114. His team along with Livermore's invented a new detector to find it.

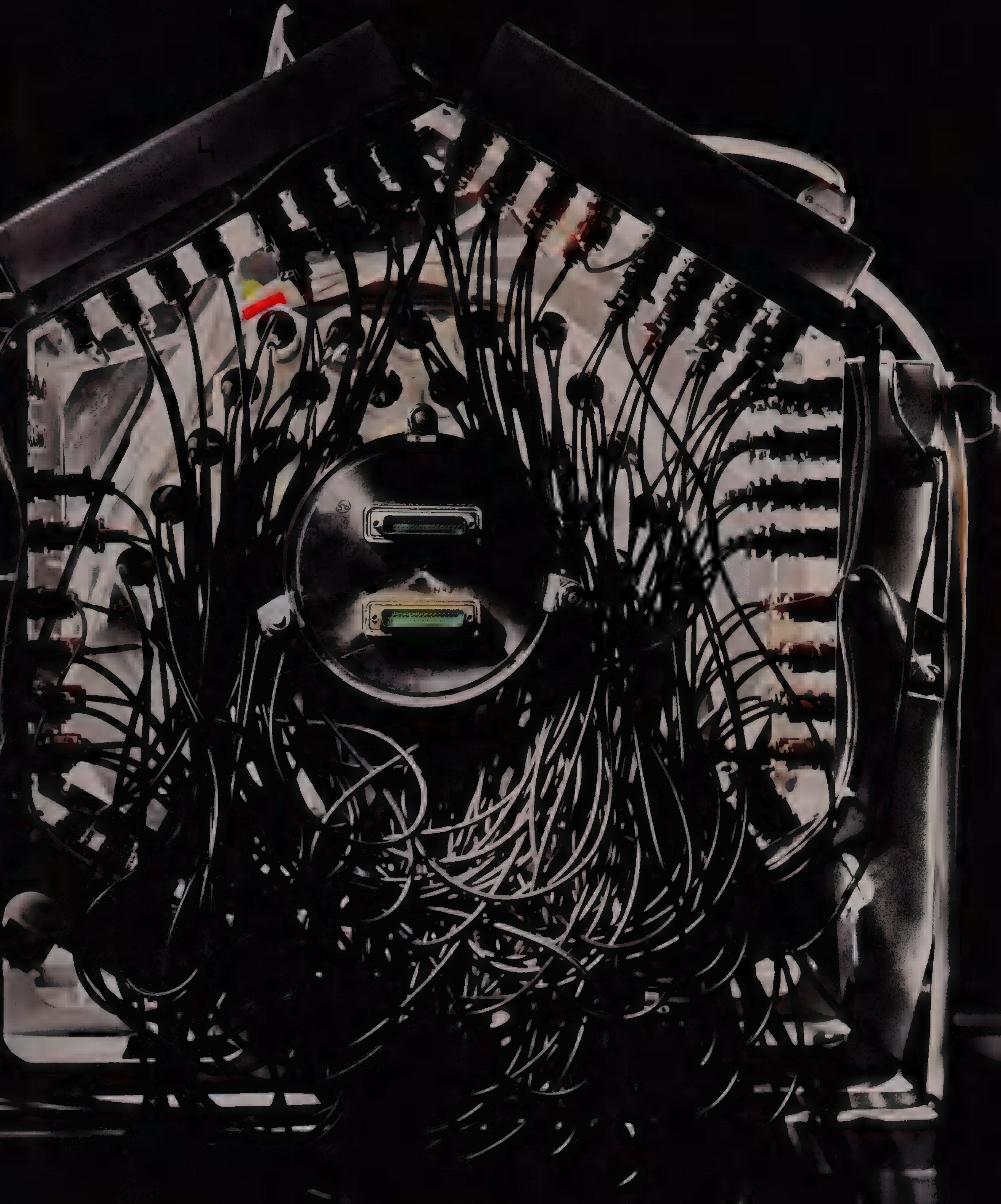
THE RESEARCHERS WENT MONTHS WITHOUT PAY. THEY GATHERED MUSHROOMS, FISHED THE VOLGA.

They turned the cyclotron on in November 1998. It required constant attention, day and night. "If the cyclotron were a person, it would be an old man," a lab technician told me. In late November the cyclotron produced a single atom of element 114. It lasted only a few seconds—but that was thousands of times longer than would be expected if there were no island of stability, and it proved that the calcium method worked. Dubna and other labs have since made elements 115, 116, 117, and 118 and isotopes with different numbers of neutrons. They're still nowhere near the island's peak, where an element might last years. But Oganessian had landed when he first made element 114, after dreaming about it for decades.

Last spring it was formally admitted to the periodic table and given a name: flerovium. (Element 116 was named livermorium.) A few months later, on Flerov Street, I leaned across the table and asked the obvious question: Does Oganessian not want to retire, at 80, to a quiet and grateful life?

"We have discovered the island," he replied. "Now it is time to explore it, to walk along its western beach." Someone needs to understand how the new elements behave, alone and in reaction with others. Someone needs to find a way to pump the magic number of neutrons, 184, into flerovium, to reach the peak of the island. Someone needs to see if there are other peaks at elements 120 or 126. At the moment those goals seem almost impossible. Oganessian won't retire yet. ☐





Creating superheavy elements is hard, identifying them can be harder. This device in Dubna detects neutrons emitted during the creation of a new element. Too fleeting to hold on to, it must be identified from its pattern of radioactive decay.

Super Materials

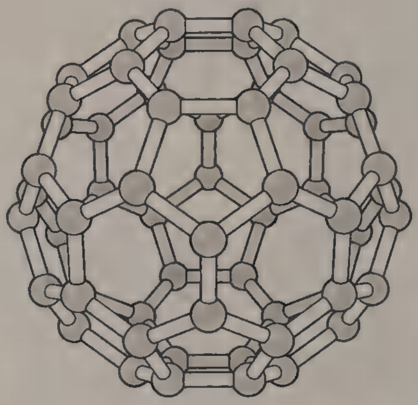
COMBINE SHRIMP SHELL and silk proteins and a miraculous new substance is born. "Shrilk" was invented by researchers at the Wyss Institute at Harvard, who layered the two components in a way that mimicked structures found in shells and insect cuticles. Shrilk is inexpensive to manufacture but has invaluable virtues: It's tough, flexible, and biodegradable. In the future it may be used to make everything from wound dressings to trash bags to disposable diapers. And it might make many landfill-choking plastics obsolete.

From the beginning of human history innovators have experimented with all kinds of elements, from the ordinary to the invisible, to try to come up with new, improved materials. The invention of plastic in 1907 inaugurated the era of synthetic materials that are stirred up in laboratories, greatly expanding the possibilities for creating an endless variety of useful products. Sometimes, though, scientists concoct materials that have no clear use at first. That's the case with the complex, record-holding kinds of carbon highlighted at right.

Other new materials may seem trivial in our high-tech world but will undoubtedly bring joy to convenience-seeking consumers. For example, a team from MIT has come up with a patent-protected, food-based formula called LiquiGlide, a slippery coating for the inside of containers that will make thick liquids like ketchup and mayonnaise glide right out. "It's like a permanent oil slick on the plastic," says team member Dave Smith. Shoppers can anticipate LiquiGlide-lined condiment bottles in a year or so. *—A. R. Williams*

WORLD'S HARDEST

Scientists crushed a naturally occurring kind of carbon called buckminsterfullerene (the molecules look like soccer balls) to create a material strong enough to dent diamonds. As yet unnamed, it may find use in industrial manufacturing and deep-well drilling.

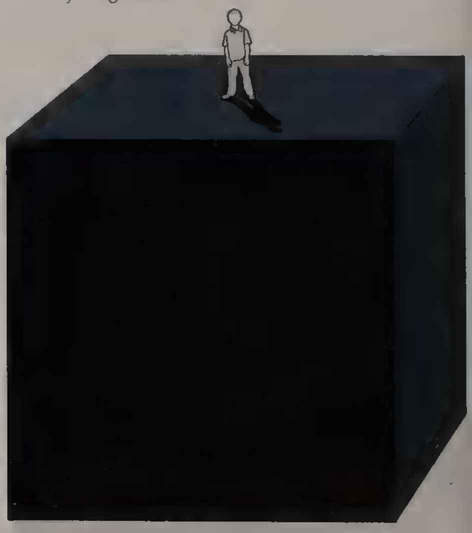


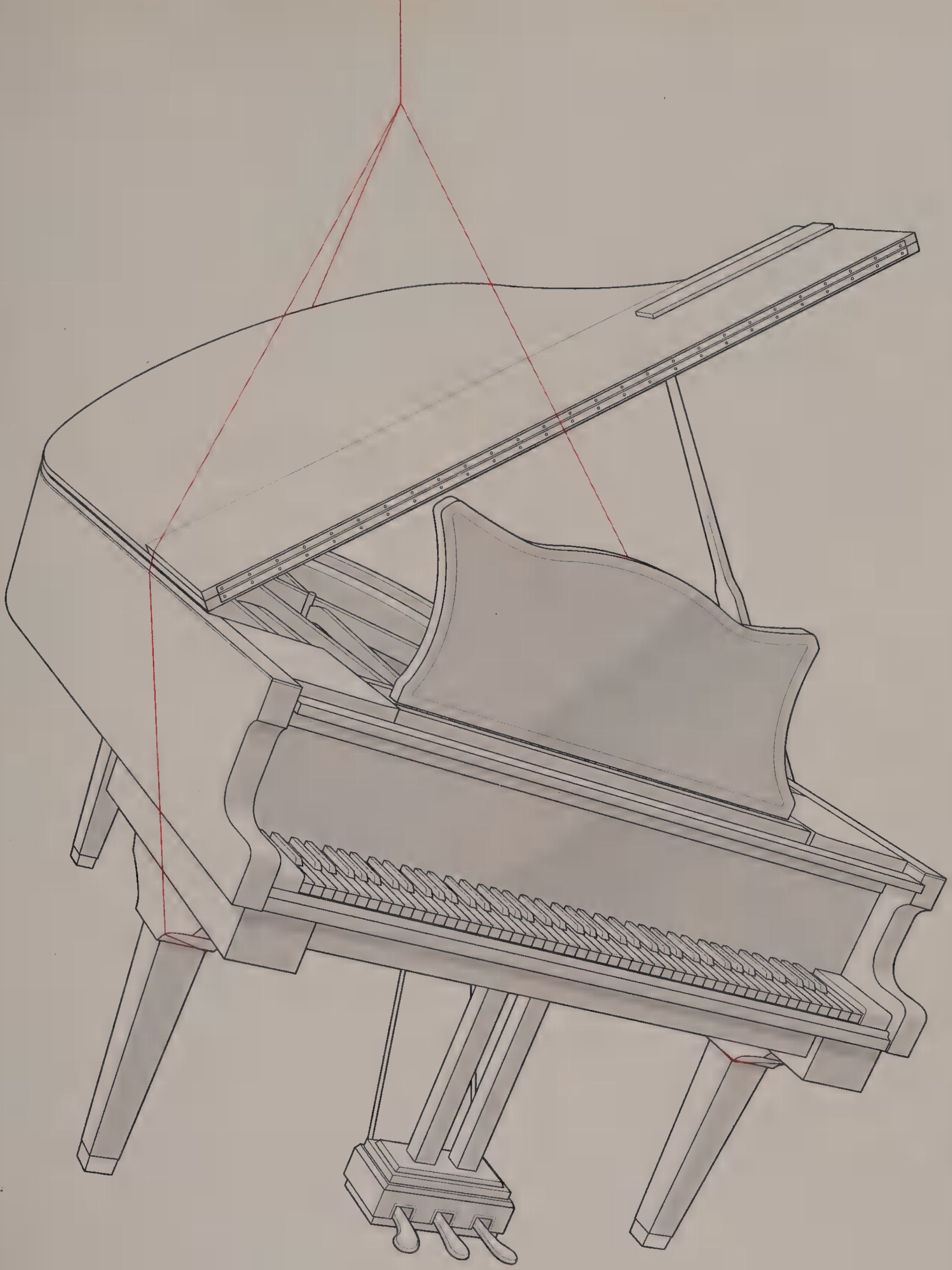
Buckminsterfullerene is named for the patent holder of a similarly shaped architectural dome.

LIGHTEST AND BLACKEST

Aerographite is a form of carbon with a spongelike structure. It is water-repellent, highly resilient, and extremely light (see note below). It also conducts electricity. Its inventors believe it could be used in electric-car batteries—a lighter load cuts operating costs. They've yet to determine how to profit from its ability to absorb almost all light, which makes it blacker than coal.

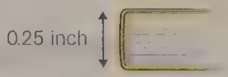
A 14-foot cube of aerographite weighs just 35 pounds, the same as a young child.





THINNEST AND STRONGEST

A human hair is almost a million times thicker than a layer of graphene. The material is made of a single layer of carbon atoms arranged in a honeycomb pattern. In theory, a string of graphene with a diameter of just one-tenth of a square millimeter—the size of a very sharp pencil point—could hold up a thousand-pound piano. To take advantage of that incredible strength, though, scientists will have to figure out a way to embed this atomic-scale element in other materials.



Imagine a single layer of graphene enlarged to the thickness of this magazine (above). At that same scale, a strand of human hair would be nearly four miles wide.

5W INFOGRAPHICS; ALEXANDER STEGMAIER, NGM STAFF
SOURCES: CARNEGIE INSTITUTION FOR SCIENCE; KIEL UNIVERSITY; HAMBURG UNIVERSITY OF TECHNOLOGY; NATIONAL GRAPHENE INSTITUTE, UNIVERSITY OF MANCHESTER

By Jeremy Berlin Photograph by Marco Grob

Flying in the Face of Peril

ÇAĞAN ŞEKERCIOĞLU is an ornithologist who works to document and prevent bird extinctions. He's also a professor in the U.S. who runs an award-winning conservation group in his native Turkey. All those pursuits require juggling—and each entails big risks.

Why do you do what you do? Who inspired you?
I've always been drawn to nature. When other kids were playing soccer, I was bringing home insects and other animals. My mom took me to a child psychiatrist! But my beloved dad is my biggest inspiration. During tough economic times he left a safe accounting job to start Turkey's first model-airplane company. It lasted 30 years.

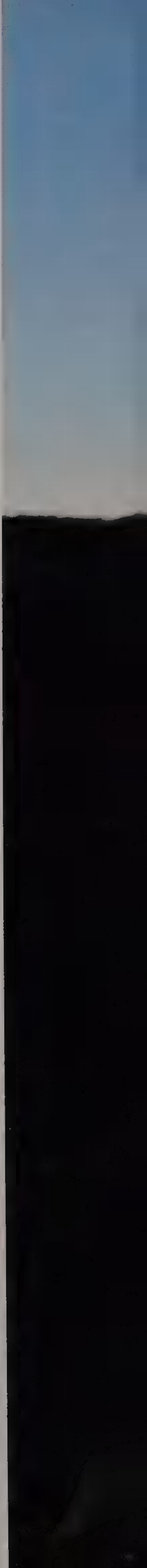
What are the physical hazards of your work?
A whole range, from the mundane to the exotic. While surveying birds I've been charged by a grizzly bear in Alaska and an elephant in Tanzania. I've tangled with a poisonous puff adder in Uganda. I've been caught between the military and terrorists, mistaken for a spy, held at gunpoint, carjacked in Ethiopia, and attacked by a machete-wielding mob in Costa Rica. Honestly, I'm often more afraid of people and traffic than I am of wildlife.

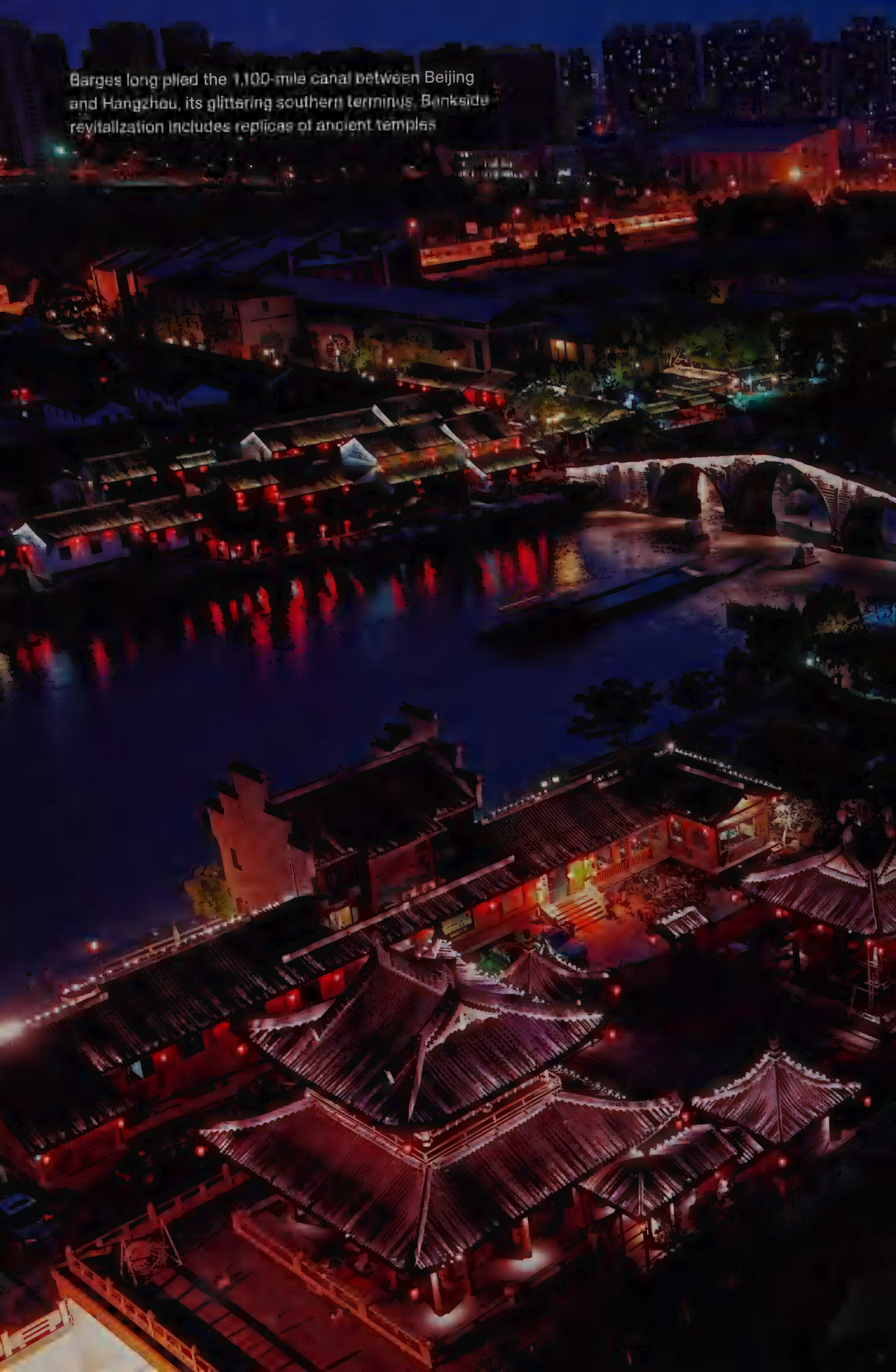
Is it politically tricky to be an environmentalist in Turkey?
It is when I criticize the institutions that grant my research permits. But it's my duty as a scientist to tell the truth. The government talks about conservation, but its priority is to convert nature into cash. So it uses doublespeak. They are reforesting while cutting down old-growth forests. Virtually every river is dammed, and the organization building those dams is responsible for regulating them. I'm trying to stop one that will destroy the Aras River wetlands, where half of Turkey's bird species live. Yet if I speak out too much, I'll be punished for a seemingly official, legal reason. Retaliation in Turkey is usually indirect.

You spend many hours on advocacy. Does that hurt your academic career?
Some academics see it as a distraction. So far my school, the University of Utah, has been very understanding and appreciative. But I have to walk a fine line.

Do you ever feel daunted by all the risks you face?
Well, I don't actively seek risk. But I don't avoid it either. Taking a risk means you can fail. But if you fail, at least you tried. And that's all I can do. If I fail in the end, I fail fighting.

Watch Marco Grob's video interview with Çağan Şekercioğlu on our digital editions.

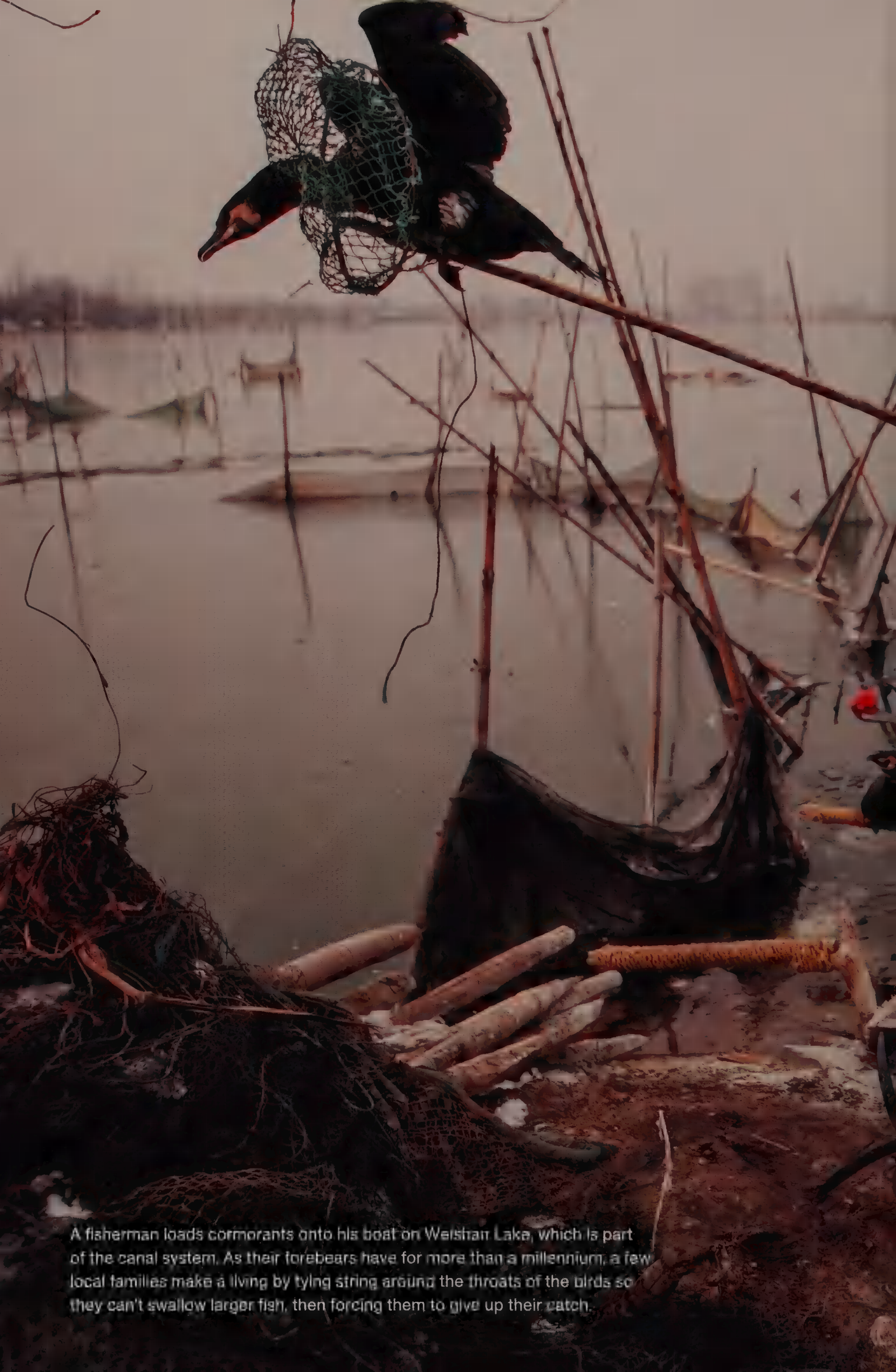




Barges long plied the 1,100-mile canal between Beijing and Hangzhou, its glittering southern terminus. Bankside revitalization includes replicas of ancient temples.

China's Ancient Lifeline

The 1,400-year-old Grand Canal is a monumental project that bound north and south China together. It's still in use today.



A fisherman loads cormorants onto his boat on Weishan Lake, which is part of the canal system. As their forebears have for more than a millennium, a few local families make a living by tying string around the throats of the birds so they can't swallow larger fish, then forcing them to give up their catch.

By Ian Johnson

Photographs by Michael Yamashita

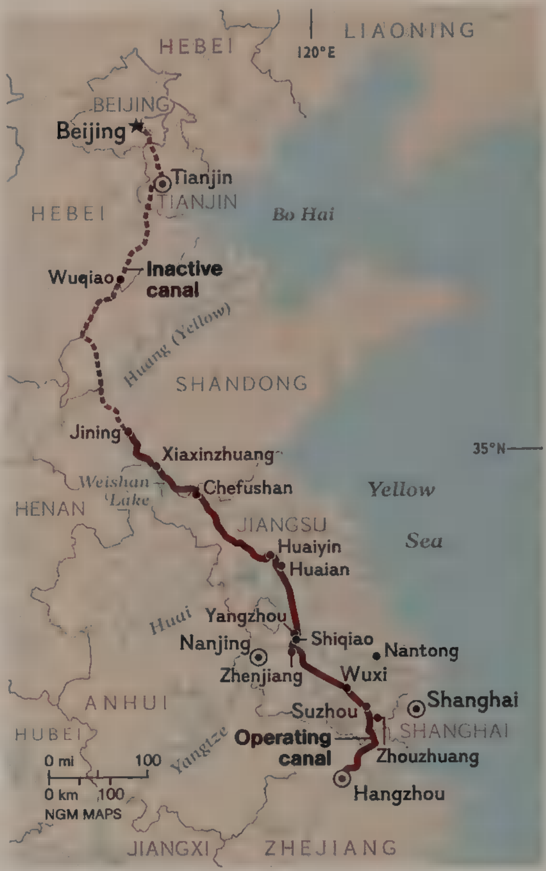
Grand Canal barges have no fancy names, no mermaids planted on the bow, no corny sayings painted on the stern. Instead they have letters and numbers stamped on the side, like the brand on a cow. Such an unsentimental attitude might suggest unimportance, but barges plying the Grand Canal have knit China together for 14 centuries, carrying grain, soldiers, and ideas between the economic heartland in the south and the political capitals in the north.

Outside the northern city of Jining, Zhu Silei—Old Zhu, as everyone calls him—fired up the twin diesels on *Lu-Jining-Huo 3307,* his shiny new barge. It was 4:30 a.m., and Old Zhu had hoped to get a jump on the other crews, who were still toying with their anchors. But as I gazed at the shore, I noticed that the trees had stopped moving against the graying sky. Looking out the other window, I was surprised to see barges overtaking us. Just then the radio crackled to life.

"Old Zhu, what's up with you?" a barge captain said, laughing. "You missed the channel!"

We had run aground. Old Zhu narrowed his eyes in disgust. He had spent six months on land supervising his barge's construction and now in his haste had underestimated the Grand Canal, with its challenging currents and its channels that silt up. Grudgingly, he picked up the mike and asked for advice.

After hearing that the sandbar was small, he stared intently at the water and decided on quick action. He reversed hard, pushing the throttle to full. The diesels shook the 165-foot barge and its thousand metric tons of coal with a mighty shudder. He spun the wheel, flipped the gear, and gunned the engines again. The waters churned as we surged ahead. With trailing lights off to save power, and the water lit only by the moon, *Lu-Jining-Huo 3307* was like a U-boat heading into enemy territory. Our target: Nantong, 430 miles to the south.


HEBEI
LIAONING
120°E
BEIJING
Beijing
Tianjin
TIANJIN
HEBEI
Bo Hai
Wuqiao
Inactive canal
Huang (Yellow)
SHANDONG
Jining
Xiaxinzhuang
35°N
Weishan Lake
Chefushan
Yellow Sea
HENAN
JIANGSU
Huaiyin
Huaian
Huai
Yangzhou
Shiqiao
Nanjing
Nantong
Zhenjiang
Wuxi
ANHUI
Suzhou
Shanghai
HUBEI
Operating canal
SHANGHAI
Yangtze
Zhouzhuang
0 mi 100
0 km 100
NGM MAPS
Hangzhou
JIANGXI
ZHEJIANG

Today's waterway

The canal flexes its commercial muscle on the 520 miles south of Jining. Much of the northern stretch is filled in or dry, though a seasonal channel runs from Jining to the Yellow River.

ON PAPER THE GRAND CANAL runs 1,100 miles, between Beijing and the southern metropolis of Hangzhou. But for nearly four decades the top half of its course—from Beijing to Jining—has been too dry for shipping. The waterway's main commercial artery now spans the 325 miles from Jining to the Yangtze.

The original canal system, built by Emperor Yang of the Sui dynasty, was seen by Chinese historians as an act of brilliant madness. Ancient China's main rivers ran west to east, and Yang wanted to break this grip of geography. He needed a way to move rice from the fertile region around the Yangtze northwest to feed his court and, crucially, his armies, which were constantly battling nomadic tribes. So the emperor's officials press-ganged an estimated million workers, mostly farmers, into building the

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Beijing-based correspondent Ian Johnson won the 2001 Pulitzer Prize for his China reporting. This is photographer Michael Yamashita's 11th China story for the magazine.

Stars of the Suzhou Kunqu Opera Theatre prep for a rehearsal. *Kunqu* opera—a stylized art form that strives for a harmonious blend of music, words, and dance—began in and around Suzhou, a canal town, in the 1500s. Performers took to the waterway to bring kunqu to the rest of China.

first section of the canal. Supervised by thousands of soldiers, the men and women were driven around the clock. Yang "inflicted intolerable sufferings," a ninth-century poet wrote, yet these projects "provided endless benefits to the people." Officially the work was finished in 171 days in the year 605, but in reality it took six years to complete and claimed an untold number of lives—many of them villagers who starved because there weren't enough hands left to harvest the crops.

The canal did more than move grain—as the country's unifying feature, it was a potent political symbol and a strategic target for invaders. In the early 1840s, when the British wanted to put a stranglehold on China during the first Opium War, they occupied Zhenjiang, at the intersection of the canal and the Yangtze, throttling the flow of grain and tax revenues to Beijing. Within weeks China surrendered.

The Grand Canal was also a cultural conduit. Emperors on visits to inspect the canal's locks and levees observed and co-opted local ways. That's said to be how Beijing acquired two trademarks: Peking duck, from Shandong Province, and Peking opera, from Anhui and Hubei. Theater troupes, who relied on the canal to get around, said prayers to its wharves, while poets were moved by its very presence. Writing in the eighth century, Zhang Ji describes a temple on the canal whose "ringing bell reaches my boat at midnight."

CANAL PEOPLE, KNOWN AS *CHUANMIN*, re-create village life on their $100,000 barges. Like farmers at harvest time, the small crews—generally

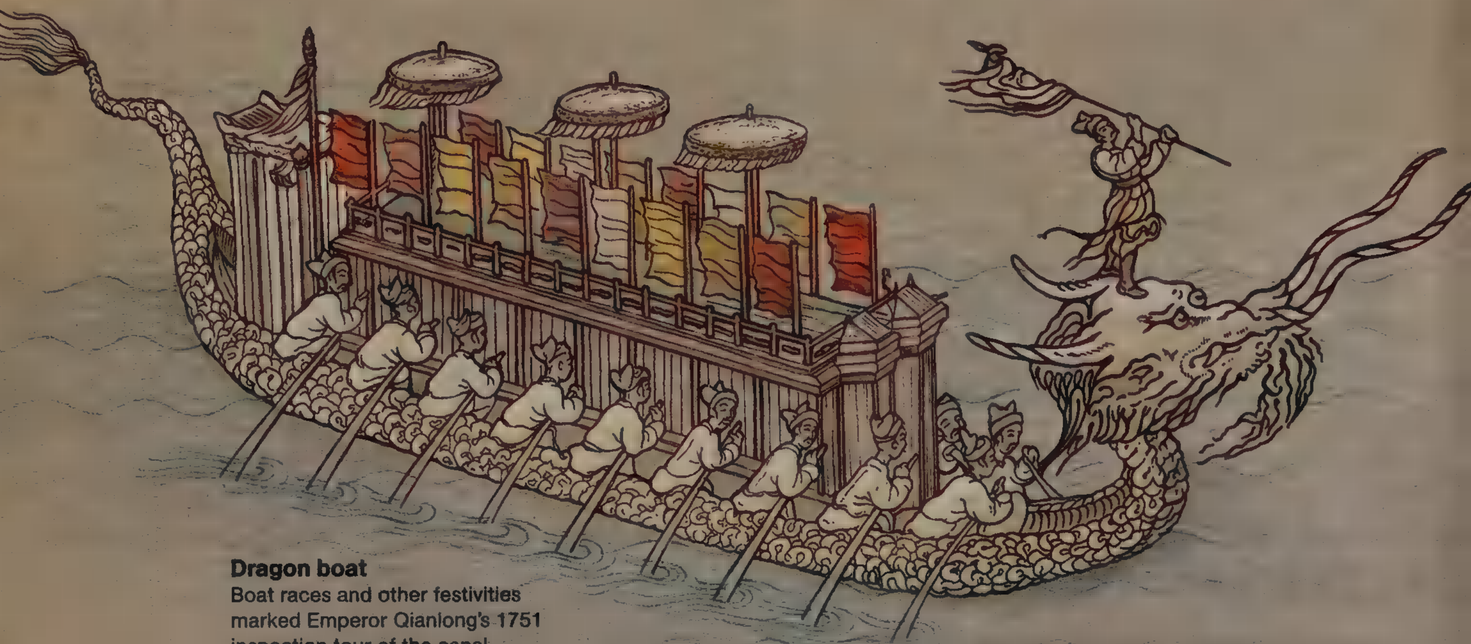
China's Grand Canal

大运河

"Grand Canal" in traditional Chinese

For centuries the power of emperors rose and fell with their control of the canal, built to link the rice-growing region of the Yangtze River, in the south, with imperial capitals above the Yellow River to the north. Soldiers handled much of the vital rice transport on this national highway, which carried everything from food and lumber to textiles, lacquer, and porcelain.

CHINA
AREA ENLARGE
TAIWAN



Dragon boat
Boat races and other festivities marked Emperor Qianlong's 1751 inspection tour of the canal.

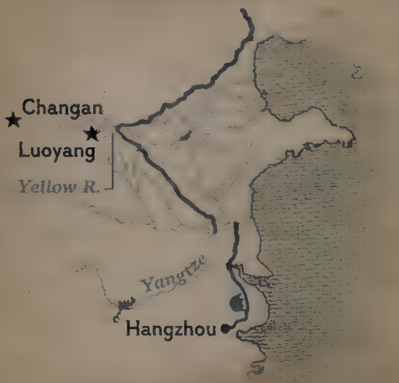
Builders of the Grand Canal

Emperor Yang

Construction Begins

A.D. 605

To bring trade to his new capital, Luoyang, Emperor Yang of the Sui dynasty built canals to connect the Yellow and Yangtze Rivers. More than two million conscripted laborers dug new channels and linked existing canals, lakes, and rivers. Completed in 611, the system grew in importance over the next 500 years.

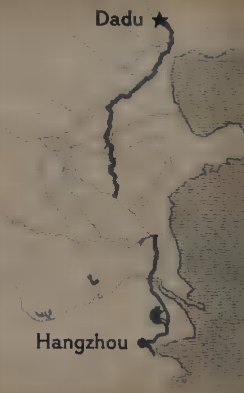


Emperor Kublai Khan

Reshaping the Canal

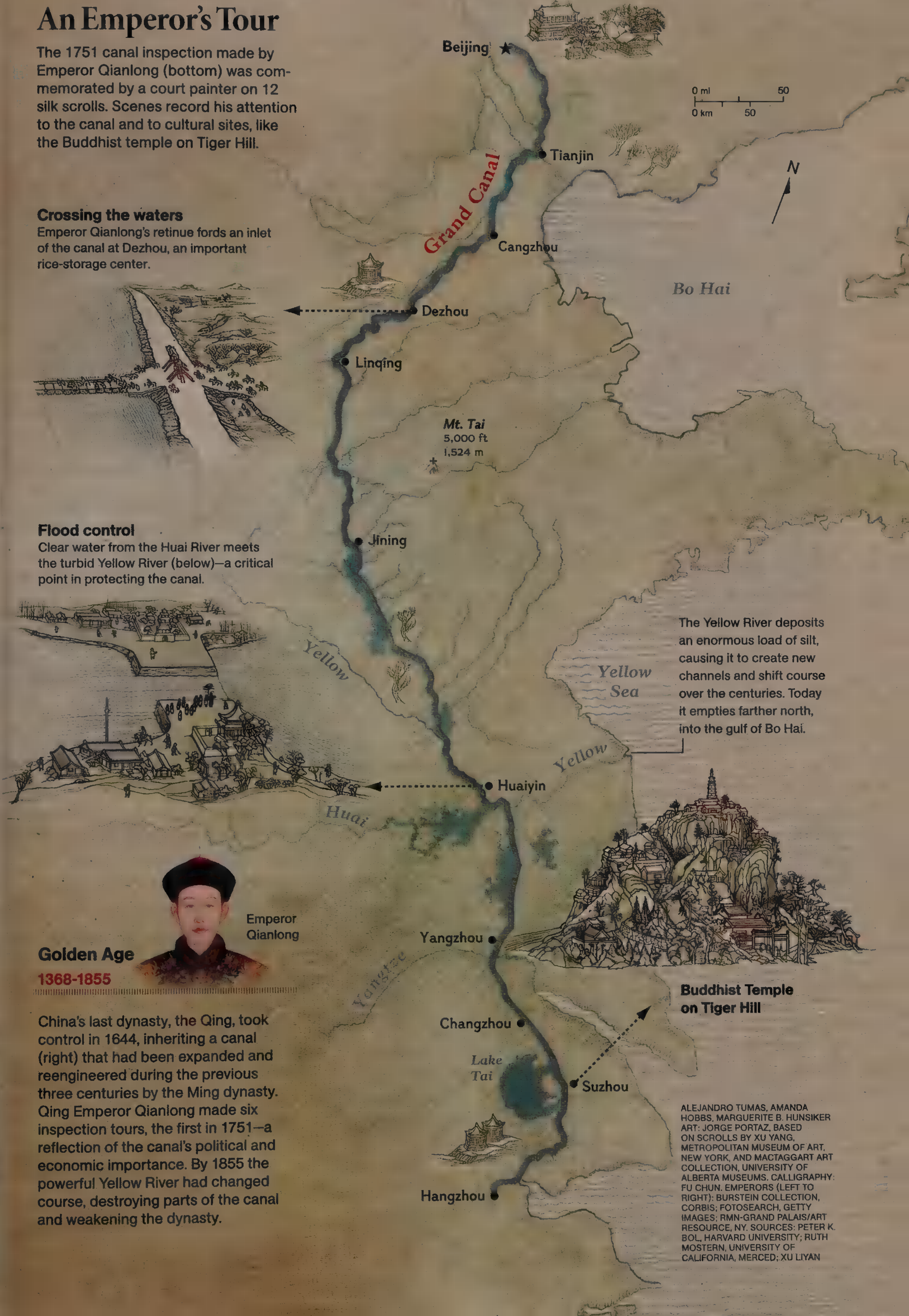
1279-1293

Parts of the Grand Canal fell into disrepair after 1127, when the besieged Song dynasty moved its capital to Hangzhou. In 1279, Kublai Khan, the first emperor of the Mongol, or Yuan, dynasty, began to revive the canal, creating a more direct north-south route to and from his capital at Dadu (today's Beijing).



An Emperor's Tour

The 1751 canal inspection made by Emperor Qianlong (bottom) was commemorated by a court painter on 12 silk scrolls. Scenes record his attention to the canal and to cultural sites, like the Buddhist temple on Tiger Hill.


Beijing
Tianjin
Grand Canal
Cangzhou
Dezhou
Linqing
Mt. Tai
5,000 ft
1,524 m
Jining
Huaiyin
Yangzhou
Changzhou
Lake Tai
Suzhou
Hangzhou
Bo Hai
Yellow Sea
Yellow
Yellow
Huai
Yangtze
0 mi
50
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N
Emperor Qianlong

Crossing the waters
Emperor Qianlong's retinue fords an inlet of the canal at Dezhou, an important rice-storage center.

Flood control
Clear water from the Huai River meets the turbid Yellow River (below)—a critical point in protecting the canal.

Golden Age

1368-1855

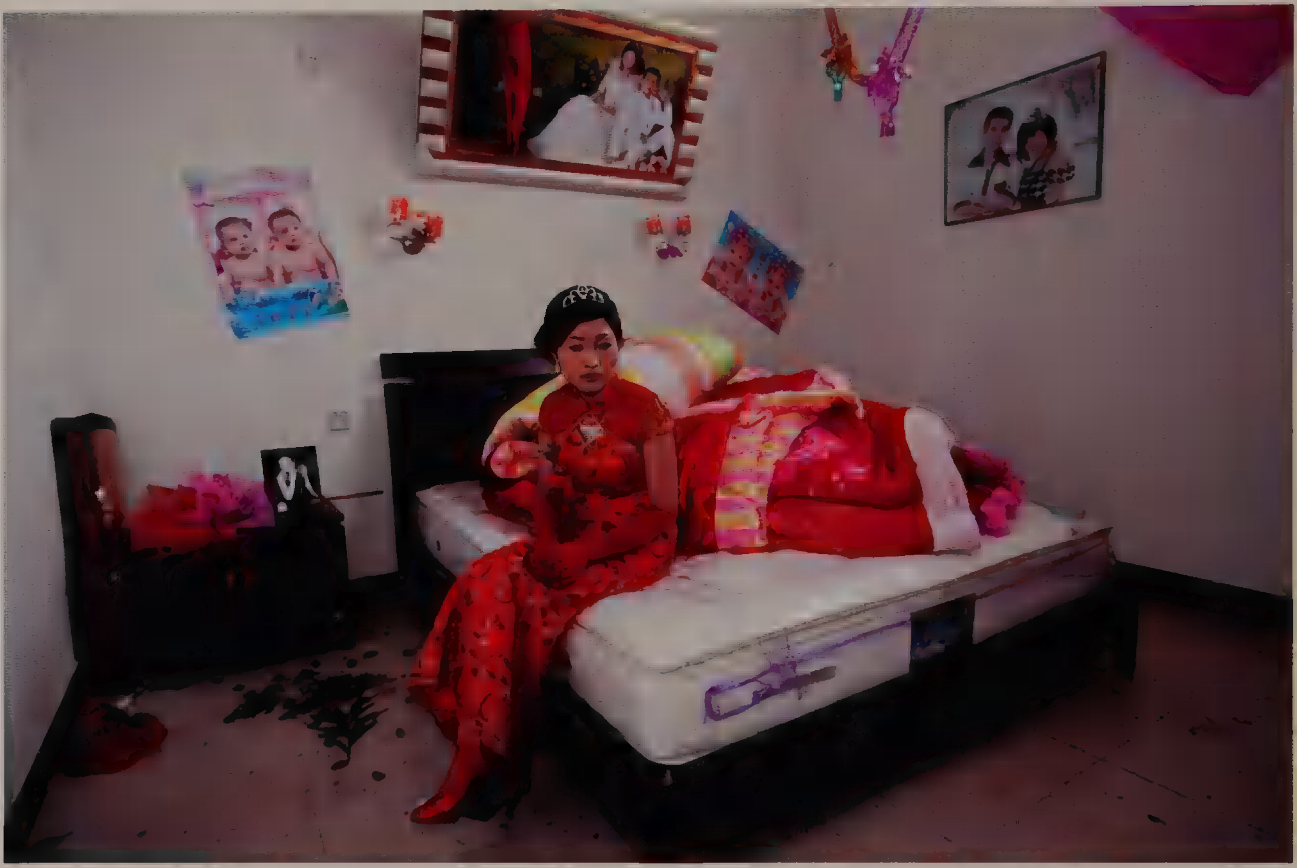
China's last dynasty, the Qing, took control in 1644, inheriting a canal (right) that had been expanded and reengineered during the previous three centuries by the Ming dynasty. Qing Emperor Qianlong made six inspection tours, the first in 1751—a reflection of the canal's political and economic importance. By 1855 the powerful Yellow River had changed course, destroying parts of the canal and weakening the dynasty.

The Yellow River deposits an enormous load of silt, causing it to create new channels and shift course over the centuries. Today it empties farther north, into the gulf of Bo Hai.

Buddhist Temple on Tiger Hill

ALEJANDRO TUMAS, AMANDA HOBBS, MARGUERITE B. HUNSIKER
ART: JORGE PORTAZ, BASED ON SCROLLS BY XU YANG, METROPOLITAN MUSEUM OF ART, NEW YORK, AND MACTAGGART ART COLLECTION, UNIVERSITY OF ALBERTA MUSEUMS. CALLIGRAPHY: FU CHUN. EMPERORS (LEFT TO RIGHT): BURSTEIN COLLECTION, CORBIS; FOTOSEARCH, GETTY IMAGES; RMN-GRAND PALAIS/ART RESOURCE, NY. SOURCES: PETER K. BOL, HARVARD UNIVERSITY; RUTH MOSTERN, UNIVERSITY OF CALIFORNIA, MERCED; XU LIYAN

The canal was seen as an act of brilliant madness. It took years to complete and claimed untold lives.



Canal villages reflect the tug of China's past and its present. Bride-to-be Wei Li, 23, wears a traditional red gown for the ceremony in the fishing village of Xiaxinzhuang, on Weishan Lake. Photos on the wall of what will be the newlywed's bedroom, taken weeks earlier, show her in Western-style garb.

just one family—start at dawn and go till evening, when they tie up their boats next to each other. Old Zhu's wife, Huang Xiling, now posted at the stern, had given birth to the family's two sons on earlier barges. She cooked, cleaned, and made the boat's little cabin a retreat from the water, wind, and sun. "The men say these boats are just a tool for making money, but our lives are spent on them," she said. "You have so many memories."

The couple's older son, Zhu Qiang, had recently taken over their previous barge. Their other son, 19-year-old Zhu Gengpeng, Little Zhu, was working on this new one, being groomed by his dad to be a captain. Little Zhu took me under his wing, translating his father's incomprehensible Shandong accent and making sure I didn't fall over the side. Gracing my quarters with his calligraphy, he wrote the words "Private Berth" above the watertight door. (My berth was a storeroom that had been converted into a guest suite by laying a plank and a quilt across two empty paint drums.)

Little Zhu doesn't look much like a chuanmin. With a rakish mustache, permanent bed head, and a purple, fur-trimmed jacket, he could be a hipster in any provincial Chinese city. He has a middle school education, and when the barge pulled up at a lock, it was Little Zhu who stepped ashore to deal with officialdom. (Although Old Zhu is only 46, he's illiterate.) Off duty, Little Zhu seemed to spend most of his time texting his girlfriend, who worked in a bakery back in Jining. He plans to bring her aboard to live in his room in the bow after they are married.

"It will be hard for her because she isn't a

Living on the water was once part of the fabric of Grand Canal life—and still is for this mother and daughter bringing provisions from the shore to their home on a retired concrete barge in Shiqiao. This kind of community is slowly vanishing as local governments clean up the canal to draw tourists.

chuanmin," Huang said. "But she's a good girl. She works hard."

CHUANMIN RARELY INDULGE THEMSELVES. They live by the hard-nosed calculations that determine whether a family gets rich or is ruined. This was driven home to me at the end of our first day. I was chatting with Zheng Chengfang, who came from the same village as Old Zhu. Our boats were tied up together, and I'd hopped over to visit with him. Wasn't it a wonderful sight, I said to Zheng as we surveyed Old Zhu's boat, freshly painted and gleaming in the sunset?

"No, no, no, you don't understand us," he blurted out. "It's not a question of good. We chuanmin need the boats, or we can't survive."

Zheng accompanied me back to our barge for a smoke with Old Zhu, while Huang cooked a simple dinner of salted fish, rice, and stir-fried greens. "If you're going to write about us, you also need to know something else," Zheng said. "We chuanmin are at the receiving end. The coal owners set the price, the moneylenders set the interest, and the government officials set the fees. All we can do is nod and continue working."

This is a common refrain among barge owners: Like peasants working the fields, they have little control over their fate. In the countryside it's the vicissitudes of weather, but chuanmin face whimsical bureaucrats and unpredictable economics. They must make complicated decisions based on everything from the direction of world commodity prices to Chinese banking reforms. Indeed, while Zheng was holding forth, Old Zhu was fixated on the TV news about the Middle East and the price of oil. "What do you

A young man herds his flock on an early morning search for food before leading the geese to the canal just south of Huaian for a swim. Many small-scale farmers in rural communities along the canal support themselves by supplying boat crews with waterfowl and meat—as well as cigarettes and beer.

On the Yangtze we were dwarfed by towering oceangoing ships, whose wakes swamped our decks.

think?" he asked me, cutting Zheng off. "Will oil top a hundred dollars a barrel? And what about steel?"

Old Zhu had taken on huge debt. His barge has a capacity of 1,200 metric tons, but the global economic slowdown meant that the coal broker in Jining had only 1,100 tons to offer. And instead of getting 70 yuan ($11) a ton, as Old Zhu had before, he'd now get 45. That meant his gross revenue for this trip would be 49,500 yuan ($7,500). He'd burn about 24,500 yuan's worth of diesel and pay more than 10,000 yuan in canal fees. On top of that there would be fines for everything from discharging wastewater to having the wrong kind of lighting. If he did well, he'd clear 5,000 yuan. But that was before the interest payment on his barge. To finance it, Old Zhu had borrowed 840,000 yuan from loan sharks at 15 percent. For this trip alone the interest would amount to 10,500 yuan. Overall, *Lu-Jining-Huo 3307*'s maiden voyage would probably lose him about 5,000 yuan.

But Old Zhu was betting that the world recession bottomed out in 2009, when he started building his barge, and that steel prices would climb, making his boat look cheap compared to ones yet to be built. He also believed that coal prices would rebound. "I'll lose money for five years but then be fine," he said, with the conviction of a Wall Street trader with a very long position on the world economy.

HALFWAY INTO OUR TWO-WEEK JOURNEY, we approached Yangzhou, chugging past willows dry-brushed with green and fields smudged with purple, red, and yellow flowers. "With flowers thick as mist, you head down to Yangzhou," Li Po, an eighth-century poet, wrote. For hours I sat with Old Zhu in the pilothouse, watching the bucolic sights give way to new highway bridges being laid atop concrete pylons.

As we cruised around one bend, Old Zhu called me out of my reverie. "That's the old Grand Canal, or what's left of it," he said, pointing to a channel about 15 feet wide curving between a small island and the bank. The Grand Canal once ran in a series of winding curves, and boats had to tack east and west as they headed north and south. When it was widened and straightened, these bends either became side channels or cutoff lakes.

"It was tough, let me tell you," Old Zhu said, his raspy voice animated. "Boats coming in every direction, and you had to pay attention all the time." His is the last generation of chuanmin who knew the old canal, with its whirlpools and eddies that could propel a barge—or ground it on a sandbar. The real miracle of the canal, it seemed to me, wasn't the structure itself but the chuanmin, whose relationship to the waterway transcends all the changes.

That night we docked on the outskirts of Yangzhou, the Shanghai of its day during two golden eras—the Tang dynasty and early Qing dynasty. Today in the booming south, local governments, awash in money, aim to bolster tourism and real estate development by beautifying and cashing in on the canal. But beautification can also destroy: Although Yangzhou has turned its waterfront into a park of manicured lawns and concrete pagodas—pleasant green space in an otherwise crowded city—the makeover required leveling nearly every canal-side building. For centuries the Grand Canal had been the heart of the city; now it's just a backdrop.

Farther south in cities such as Zhenjiang, Wuxi, and Hangzhou, the situation is worse. The canal still runs through Hangzhou's industrial center, but with the exception of the elegantly arched Gongchen Bridge, every structure linked to it—every ancient dock, warehouse, and mooring point—has been razed. "Traditionally we talk about 18 main cities on the Grand Canal, and each had its special flair," Zhou Xinhua, then vice director of a Grand Canal museum in Hangzhou, told me. "But now they're all the same: a thousand people with one face."

In 2005 a small group of prominent citizens called for the historic Grand Canal to be made a UNESCO World Heritage site. "Every generation wants the next generation to understand it, to look at its monuments," Zhu Bingren, a sculptor who cowrote the proposal, told me in an interview. "But if we wipe out the previous

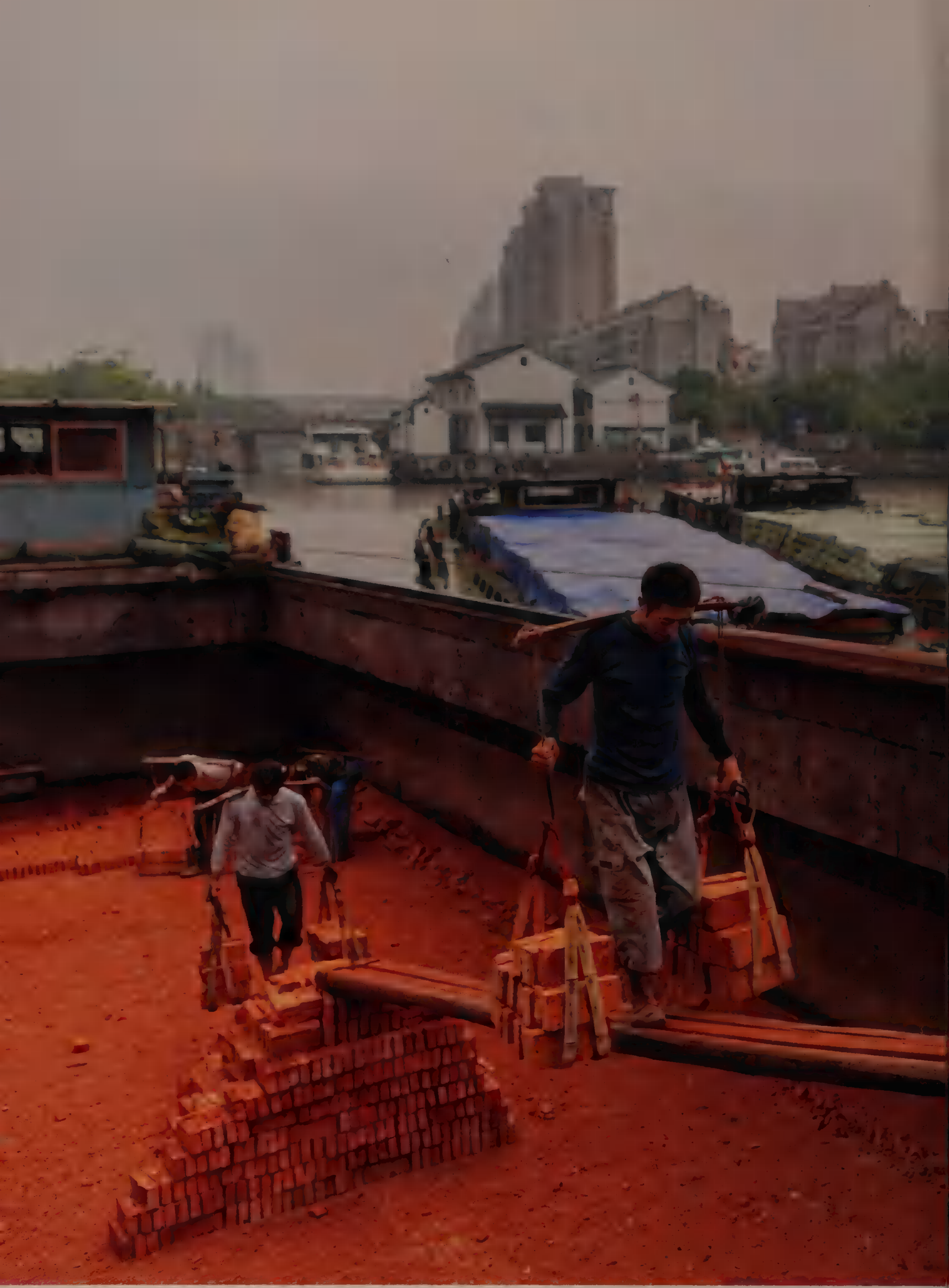
Three-year-old twins are among the youngest students at the Changfa Acrobatic School in Wuqiao County. Their program includes tumbling, juggling, and a basic education; tuition, room, and board is $150 a year. Though the canal is now dry in this area, it once ferried acrobats to performances in port towns.

generations' work, what will following generations think of us?"

AT DAWN ON DAY EIGHT we turned east and joined the Yangtze. Now we were dwarfed by towering oceangoing ships, whose wakes swamped our decks. "The Yangtze is like a highway, and we are like a small car, so we have to go carefully and get off as quickly as possible," Old Zhu said. Within three days we had reached our destination: the Nantong Fertilizer Plant. Because of heavy rains, it took four days to unload the barge, the hull rising imperceptibly as the crane clawed out the coal. Old Zhu then hightailed it back along the Yangtze to the canal.

After a night moored in a cove near Yangzhou, everyone was up at dawn to get the barge moving. Rubbing the sleep from his eyes, Little Zhu untied the thick bow ropes. Old Zhu started an electric winch that pulled up the anchor. Huang cast off from the stern and stood watch. A light current carried us away from the willow-lined shore, pushing the stern out into the canal. Old Zhu walked from the winch to the pilothouse, calmly lighting a cigarette as we glided the wrong way. He pushed the starter, and the twin diesels rumbled to life.

Barely looking back, he reversed the boat into the main channel, an act of bravura that said, This is my canal as much as anyone's. He turned the bow upstream as other barges bore down. Then, after a dramatic pause, Old Zhu pushed the throttle full ahead. The engines surged, the propellers bit, and *Lu-Jining-Huo 3307*, green and shining in the soft spring light, joined the endless flow of traffic on the Grand Canal. □



The load of bricks that each stickman carries weighs about 200 pounds. The porters, at Beixinqiao dock in Hangzhou, get the nickname from the handmade bamboo poles they sling across their backs to haul goods. Muscle power has been replaced by cranes and trucks along much of the canal.

Every month this page features our staff picks of National Geographic Society products and events. For more go to *nglive.org*.

NATIONAL GEOGRAPHIC ON TV

Brain Games

Scientists are on an endless quest to unlock the human brain's mysteries. For example, what makes us lie or feel attraction? Back for its second season, *Brain Games* tackles these questions and more with interactive experiments and, yes, games (involving boxes and a sledgehammer at left). The fun—with a side of neuroscience and psychology—starts this month on the National Geographic Channel.

EVENT

GEOGRAPHIC BEE Where would you find the Karoo? How about Teotihuacan? Students competing in this year's National Geographic Bee know the answers. Watch the finalists of the 25th annual bee, hosted by Alex Trebek, compete live May 22 in Washington, D.C. For tickets visit *nglive.org/geobee*.

TRIPS

125TH ANNIVERSARY TRIPS Travel with our experts on trips—including a voyage with stops in Brazil (right)—crafted in honor of the Society's big year. See *ngexpeditions.com/125trips*.

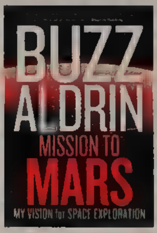
LECTURE

EXPLORERS EVENING Join top explorers at a Washington, D.C., symposium as they look ahead to a new year of discoveries. Find tickets for the June 11 panel discussion at *nglive.org*.

ACTIVITY

BIOBLITZ Team up with scientists, students, and other volunteers to tally the species living in Louisiana's Jean Lafitte National Historical Park and Preserve. The bioblitz and accompanying festival are on May 17 and 18. Go to *nationalgeographic.com/bioblitz* to register.

Book of the Month



Mission to Mars Buzz Aldrin with Leonard David

Astronaut Buzz Aldrin is a lifelong advocate of planetary exploration. His new book is a rallying cry for fans of the space program, laying out his vision for taking humans beyond the moon to Mars by 2035. Aldrin's blend of history, policy, and science will appeal to professional and amateur space enthusiasts alike. Available May 14 ($26).

PHOTOS: SCOTT GRIES, NATIONAL GEOGRAPHIC CHANNEL (TOP); OSTILL, SHUTTERSTOCK

NOTICE OF PROPOSED SETTLEMENTS

If You Purchased Potash Indirectly For End Use And Not For Resale In The United States Between July 1, 2003 And January 30, 2013, From JSC Uralkali, JSC Silvinit, JSC Belarusian Potash Company, BPC Chicago L.L.C., JSC International Potash Company, Agrium, Inc., Agrium U.S., Inc., The Mosaic Company (N/K/A MOS Holdings Inc.), Mosaic Crop Nutrition, LLC, Potash Corporation Of Saskatchewan Inc., Or PCS Sales (USA), Inc., Your Rights May Be Affected And You May Be Entitled To A Benefit.

The purpose of this notice is to inform you that two settlements have been reached in *Potash Antitrust Litigation (II)*, MDL Dkt. No. 1996, No. 1:08-CV-6910, a putative class action pending in the United States District Court for the Northern District of Illinois. The lawsuit alleges that several large potash producers ("Defendants") conspired to restrict the supply of potash, and to raise and fix its price. Potash is a mineral or chemical salt, used mainly in fertilizer. The Defendants have agreed to settle the lawsuit in two separate settlements.

In the first settlement, Defendants JSC Uralkali and JSC Silvinit (as well as JSC Belarusian Potash Company, BPC Chicago L.L.C. and JSC International Potash Company, collectively the "Foreign Settling Defendants") settled the claims against them in this litigation for $2,750,000.00 and important cooperation. In the second settlement, Defendants Agrium, Inc., Agrium U.S., Inc., The Mosaic Company (n/k/a MOS Holdings Inc.), Mosaic Crop Nutrition, LLC, Potash Corporation of Saskatchewan Inc., and PCS Sales (USA), Inc. (collectively, the "North American Settling Defendants") have agreed to settle the claims against them, which are all of the remaining claims in the indirect purchaser action, for the sum of $17,500,000.00. The Defendants deny they did anything wrong.

The Court will hold a public fairness hearing on **June 12, 2013, at 1:30 p.m.** to consider (1) whether to give Final Approval to the Settlements and approve the Plan of Allocation, (2) whether to approve Class Counsel's request for attorneys' fees and reimbursement of expenses from the Settlement Funds; and (3) whether to approve the incentive awards for the Class Representatives. You or your own lawyer may ask to appear and speak at the hearing. If you wish to appear, you must file a Notice of Appearance received by **May 29, 2013.**

A copy of the Settlement Agreements, the formal Settlement Notice, Proof of Claim, Plan of Allocation and other important documents are available on the settlement website at PotashIndirectSettlement.com. For additional information, you may also contact the Settlement Administrator (A.B. Data, Ltd.) at 1-866-778-9623.

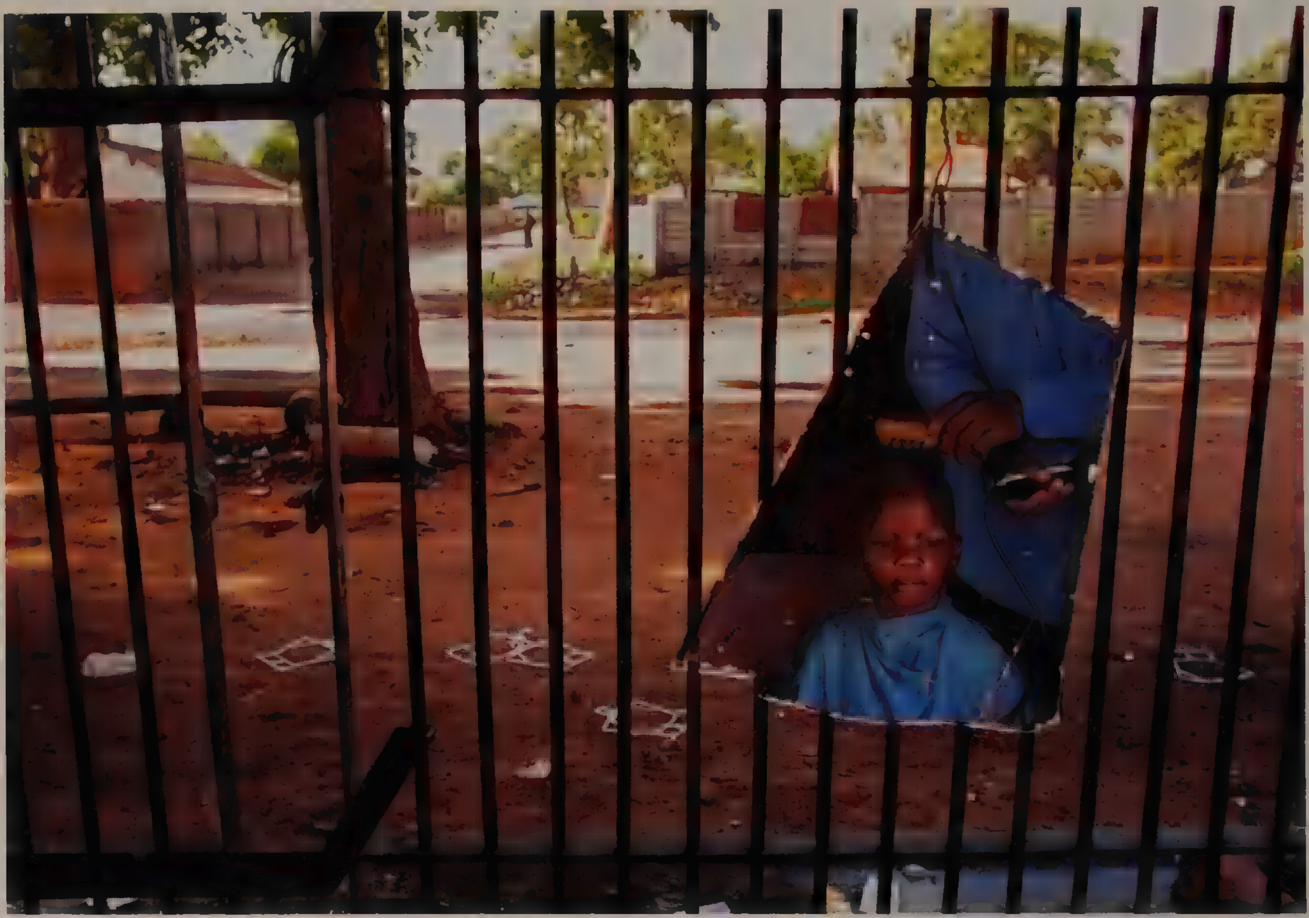
If you are a member of either Settlement Class, you may seek to participate in the corresponding Settlement by submitting a Proof of Claim on or before **September 2, 2013**. You may obtain a Proof of Claim on the settlement website referenced above. If you are a member of one of the Settlement Classes but do not file a Proof of Claim, you will still be bound by the releases set forth in the Settlement Agreements if the Court enters an order approving the settlements. All objections and requests to be excluded from the settlements must be made in accordance with the instructions set forth in the formal Settlement Notice and filed with the Court and served on the Parties' counsel by **May 22, 2013.** The formal Settlement Notice is available on the settlement website referenced above.

For More Information: Call 1-866-778-9623 or Visit PotashIndirectSettlement.com
Dated: February 20, 2013

THE MOMENT *Robin Hammond*

Caught in Zimbabwe

To document human rights abuses, photojournalist Robin Hammond first went to Zimbabwe in 2007. After several visits and two arrests for taking photos in unauthorized places, he spent 26 nights in prison and was deported last year. Hammond was particularly struck by Mbare, an impoverished suburb of the capital. In an outdoor stairwell he spotted a boy getting his hair cut and looking at his reflection in a piece of a broken mirror hung against bars—a metaphor for a broken country unable to see the world beyond itself. *—Daniel Stone*



BEHIND THE LENS

Why did you want to tell Zimbabwe's story?

RH: This is a country that once fought for Robert Mugabe's promise of a free Africa. Instead of getting freedom, its people have been oppressed by a dictator. The idea of my project was to document the lives of people on the front lines of Mugabe's efforts to stay in power. It was important for me to show how their lives continue, even with the intimidation and political volatility.

How did you report while staying covert?

I became accustomed to 4 a.m. starts, when there would be fewer people and thugs around who might interfere with my work. Once news got out that a white man with a camera had been seen, the security agents would come looking for me.

How did you persuade people to let you photograph them?

I promised I wouldn't use their last names or be specific about where I met them. Some people declined out of fear, but many more welcomed me. It seemed easier to talk to people who had been victims of Mugabe's party because I am white. They knew I couldn't be a secret agent.

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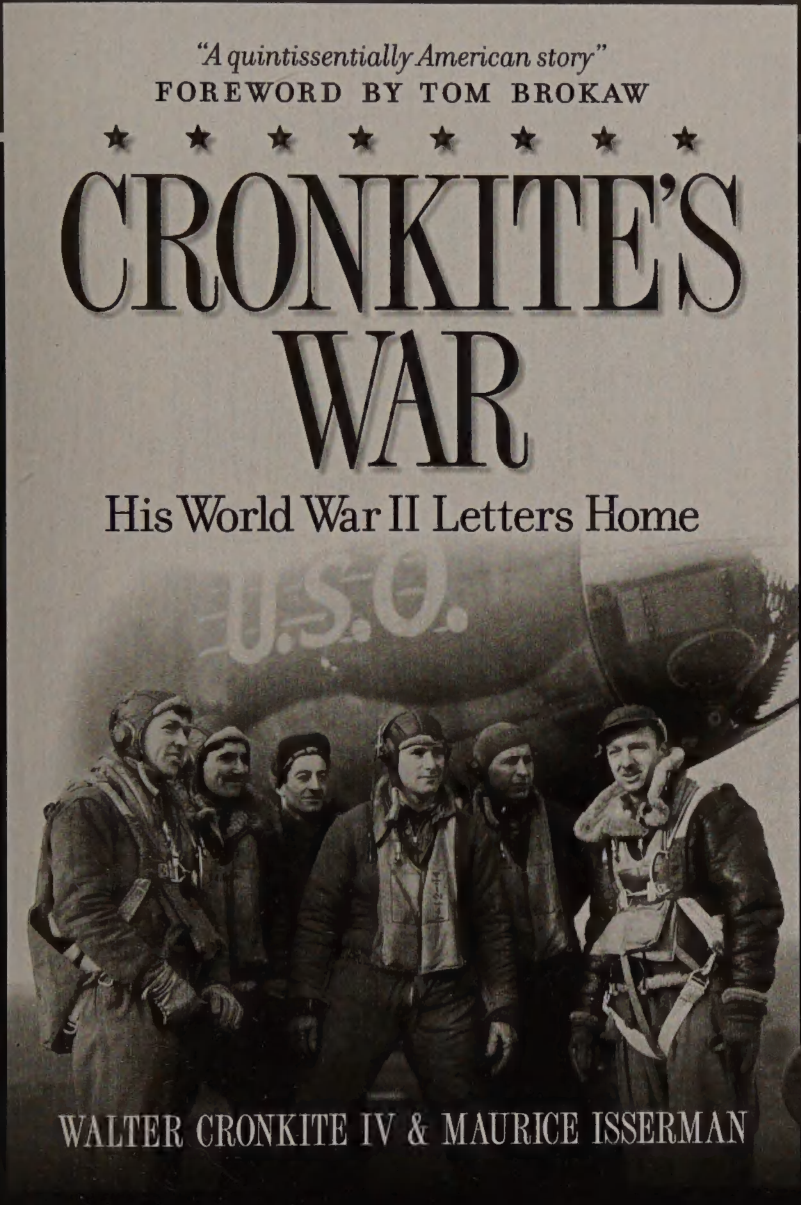

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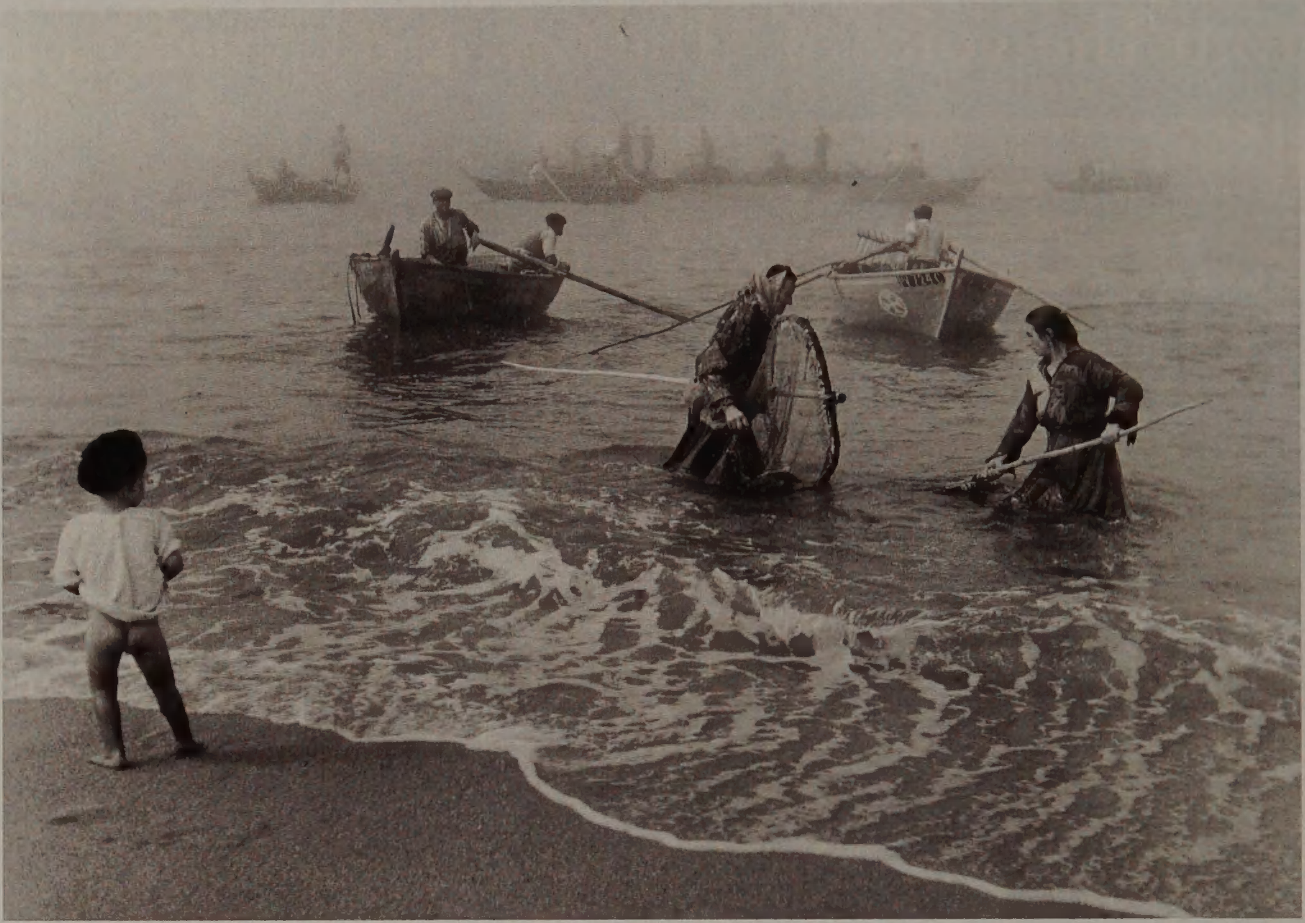

Netting Profits

"On the northern coast [of Portugal], at some small localities by the names of Apulia and Ver-O-Mar," say the notes accompanying this 1950s photo, "the inhabitants occupy themselves with the gathering of sargassum and various sea-weeds which they gather in big nets. The 'harvesting' takes place near the coast, for the rough sea brings huge quantities."

Today the bulk of seaweed collected is for human consumption, not for fertilizing local fields, as this Portuguese take was. Production is dominated by Asian countries, often China and Japan. In Europe most seaweed is brought in mechanically, though some is still harvested by hand, using knives, rakes, pitchforks, sickles, and nets. Portugal is the only European producer of the briny commodity to employ diving. *—Johnna Rizzo*

Flashback Archive Find all the photos at **ngm.com.**

PHOTO: ARTHUR PASTOR, NATIONAL GEOGRAPHIC STOCK

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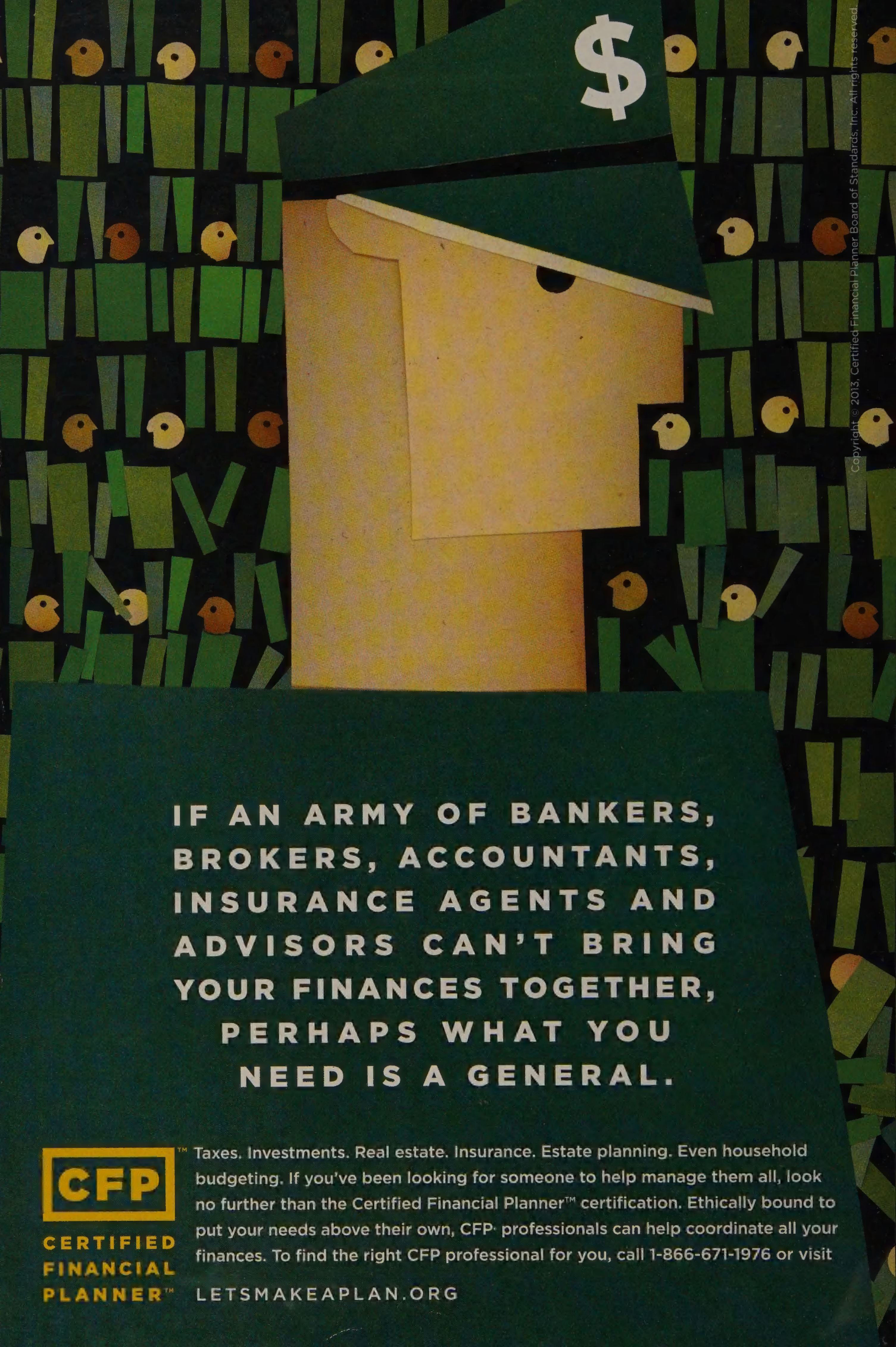

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